

- ⁶ Kostoff, D., *Bul. Cult. Ferment. Tutun.*, **28**, 165-178 (1939).
- ⁷ Goodspeed, T. H., and Bradley, M. V., *Bot. Rev.*, **8**, 271-316 (1942).
- ⁸ Goodspeed, T. H., and Clausen, R. E., *Univ. Calif. Publ. Bot.*, **11**, 245-256 (1928).
- ⁹ Kostoff, D., *Am. Jour. Bot.*, **28**, 112-113 (1931).
- ¹⁰ Clausen, R. E., *Svensk. Bot. Tidsskr.*, **26**, 123-136 (1932).
- ¹¹ Greenleaf, W. H., *Am. Nat.*, **75**, 394-399 (1941).
- ¹² Smith, H. H., and Smith, C. R., *Jour. Ag. Res.*, **65**, 347-359 (1942).
- ¹³ Noguti, Y., Oka, H., and Otuka, T., *Jap. Jour. Bot.*, **10**, 343-364 (1940).
- ¹⁴ Holmes, F. O., *Phytopath.*, **28**, 553-561 (1938).
- ¹⁵ Kostoff, D., *Cur. Sci.*, **7**, 108-110 (1938).
- ¹⁶ Smith, H. H., *Jour. Hered.*, **30**, 291-306 (1939).
- ¹⁷ Warmke, H. E., and Blakeslee, A. F., *Ibid.*, **30**, 419-432 (1939).
- ¹⁸ Mendes, A. J. T., *Bol. Technico (Brazil)*, No. 57 (1939).
- ¹⁹ Bartolucci, A., *Boll. Tecn. R. Ist. Sper. Tab. Scafati*, **36**, 141-148 (1939).
- ²⁰ Nebel, B. R., and Ruttle, M. L., *N. Y. Agr. Expt. Sta. Cir.*, No. 183 (1938).
- ²¹ Lammerts, W. E., *Genetics*, **14**, 286-304 (1929).
- ²² Lammerts, W. E., *Ibid.*, **16**, 191-211 (1931).
- ²³ Little, T. L., *Science*, **96**, 188-189 (1942).

CHROMOSOMAL ABERRATIONS IN BRAZILIAN *DROSOPHILA ANANASSAE*

BY TH. DOBZHANSKY* AND ANDRÉ DREYFUS

COLUMBIA UNIVERSITY, NEW YORK, AND UNIVERSITY OF SÃO PAULO, BRAZIL

Communicated September 27, 1943

Drosophila ananassae de Meijere is a species common in or close to human habitations in the tropical and subtropical parts of the world. Most of its relatives are confined to eastern and southern Asia. It seems reasonable to suppose that *D. ananassae* is also a native of these lands; its presence elsewhere, particularly in the Americas, is due to introduction by man. A study of the chromosomal variability confirms this conjecture. As shown below, Brazilian populations contain mostly the same chromosome variants which occur in southeastern United States and in eastern Asia. Such a uniformity of intraspecific chromosome variants could hardly occur if the present wide distribution of the species would be entirely a "natural" one. In one of the Brazilian populations we have, however, established the presence of translocation heterozygotes. While inversions occur in most species of *Drosophila*, this is the first instance of a translocation being found in a population of *Drosophila* outside genetic laboratories.

We have received population samples of *D. ananassae* from Bello Horizonte (state of Minas Gerais) collected by Mr. José Pellegrino, from Rio de Janeiro collected by Professor Hugo Souza Lopes, from Mogi das Cruzes

collected by Mr. C. Pavan, from Santos and São Vicente collected by Mr. Aylthon Joly, and from Itanhaem collected by Mr. Edmundo Nonato; the last four localities are in the state of São Paulo. *D. ananassae* has four pairs of V-shaped chromosomes at metaphase, represented in the salivary gland chromosomes by four long (autosomal), two shorter (*X*-chromosome), and one very short (autosomal) chromosome strands. A study of the salivary gland chromosomes of the offspring of females collected outdoors showed that only about 7 per cent of the individuals (8 out of 118) are free of inversions, while the remainder are heterozygous for from one to four inversions. The commonest inversion is the subterminal one in the left

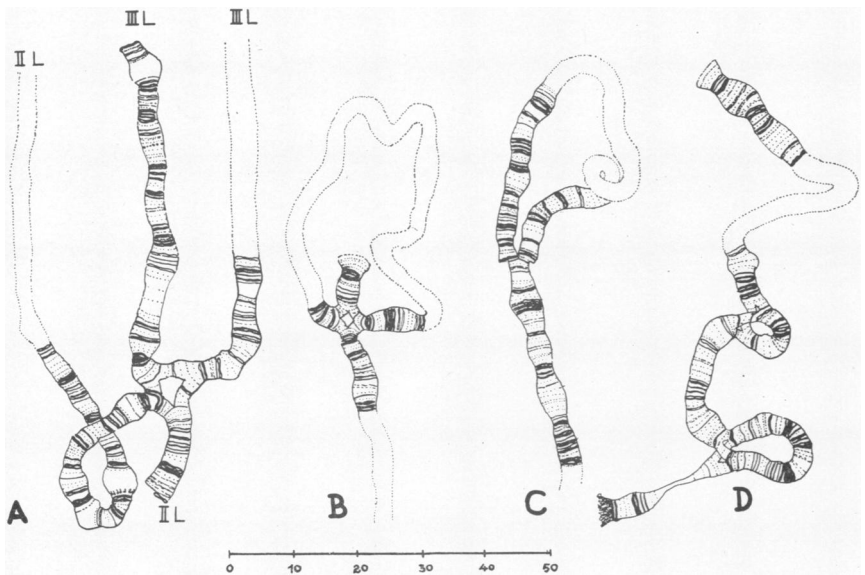


FIGURE 1

A, a translocation between the left limbs of the second and the third chromosomes. Note a deficiency of the terminal disc on one side in the tip of II *L*. *B*, subterminal inversion in II *L*. *C*, apparently terminal inversion in III *L*. *D*, basal and median inversions in III *R*. The scale represents 50 micra.

limb of the second chromosome (II *L*) shown in figure 1, *B*; about one-half of individuals in all the localities are heterozygotes for the inversion. The next commonest is the apparently terminal inversion in the left limb of the third chromosome (III *L*) shown in figure 1, *C*; about 40 per cent of the flies in all the localities are heterozygotes for this inversion. The small inversion in the basal part of the right limb of the third chromosome (III *R* basal, Fig. 1, *D*) was also found in all localities, but only about 30 per cent of the flies are heterozygotes. A small inversion in the middle part of the right limb of the third chromosome (III *R* median, Fig. 1, *D*) occurred in

three individuals from Bello Horizonte. Finally, an inversion in the middle portion of the right limb of the second chromosome (II R, figured by Kikkawa¹ on his plate I J) occurred in several individuals from Mogi das Cruzes, Rio de Janeiro, Santos and São Vicente. Kaufmann² found in Alabama populations the inversions II L, III L, II R and III R basal. Kikkawa¹ found in populations of several localities in Japan and in Shanghai, China, the inversions recorded by Kaufmann in Alabama, plus a small

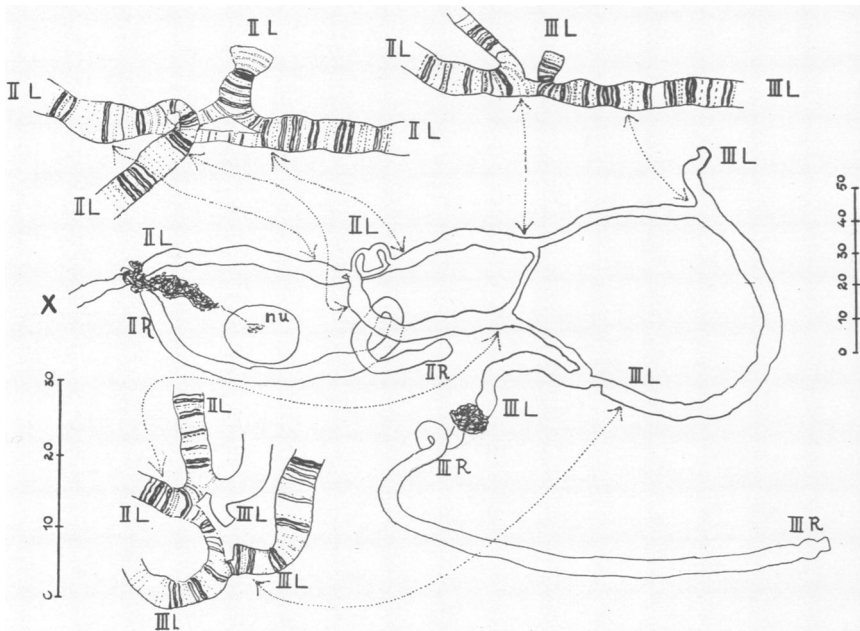


FIGURE 2

In the center, an outline drawing of the configuration resulting from a combination of the translocation and two inversions in the left limbs of the second (II L) and the third (III L) chromosomes; II R and III R, respectively, the right limbs of the second and the third chromosomes; X, X-chromosome; nu, nucleolus; the chromocenter is shown as a body with a reticulate structure; the magnification is indicated by the scale on the right representing 50 micra. The drawings above and below the outline show details of the structure of the critical portions as seen in other cells; the scale on the left represents 30 micra and is applicable to the detailed drawings.

inversion in II L in a single strain from Taihoku recorded neither by Kaufmann nor by ourselves. Our III R median inversion from Bello Horizonte is, thus, the only not previously known one. The translocation between the third and the fourth chromosomes described by Kikkawa¹ is a laboratory product.

In a strain coming from one of the seven females collected at Mogi das Cruzes, there occurred the highly complex chromosome configuration rep-

resented in outline in figure 2. The left limbs of the second and third chromosomes are, in this configuration, taking part in the formation of two closed rings; the right limbs of the second and the third, and the X and fourth chromosomes are normal. A careful examination of the disc patterns in the critical regions of the chromosomes in the configuration just referred to (see the drawings in Fig. 2 showing the disc patterns; these drawings have been made from several cells, at a magnification higher than the outline in the central part of this figure) has led to the conclusion that a reciprocal translocation between the left limbs of the second and third chromosomes as well as the II *L* and III *L* inversions are involved. An interpretation of the configuration of figure 2 is shown schematically in figure 3. In this latter figure the normal left limb of the second chromosome is shown dotted; the normal left limb of the third chromosome black; the left limbs of the second and third chromosomes involved in the translocation white and cross-hatched, respectively. The base and a part of the inverted portion of the second chromosome (white) has acquired most of the inverted terminal portion of the third chromosome (cross-hatched); the base of the third chromosome (cross-hatched) has acquired part of the inverted portion and the uninverted tip (white) of the second chromosome.

Chromosomes with and without the II *L* and III *L* inversions are both found in the populations studied by us. Therefore, if the interpretation given to the configuration shown in figure 2 is correct, we should be able to find much simpler configurations showing the translocation with only II *L*, or only III *L* inversion, or without either inversion. The characteristics of these configurations are predictable, and they have indeed been found in the salivary glands of other larvae from the same culture which showed the configurations of figures 2 and 3, as well as in another culture obtained from a female caught at Mogi das Cruzes. Figure 1, *A* shows the translocation configuration without the complicating inversions. This is a typical cross-shaped configuration observed in translocation heterozygotes.

It appears, then, that two of the seven females collected at Mogi das Cruzes were either translocation heterozygotes or have mated with translocation males. Unfortunately, the translocation stock has been lost before the viability of the translocation homozygotes and related problems could be studied; new population samples from the same locality have as yet not been obtained. Since translocation heterozygotes in *Drosophila* usually have a fertility below that of homozygotes, translocations are not expected to be retained in natural populations, and the case just described is so far the only one on record.

Other "forbidden" classes of chromosome changes are terminal deficiencies, duplications and inversions. The terminal chromomere ("telomere") is supposed to be a structural element without which a chromosome cannot exist, and which cannot be replaced by a chromomere usually oc-

cupying an interstitial position. The III L inversion has been described by Kaufmann² as a terminal one, and we can confirm that it is visibly so. Kikkawa¹ described variations in the structure of the free ends of the second and third chromosomes in *D. ananassae* which appear as deficiencies of a single or a few terminal discs (or as additions of new discs not present in that location in other strains). We find in Brazilian populations variations apparently identical with those described by Kikkawa. An instance of a heterozygous deficiency for a terminal disc in the left limb of the second chromosome is shown in figure 1, A. The nature of these terminal deficiencies (or duplications) is unclear, but in any case they have nothing to do with the "pseudotranslocations" allegedly found by Goldschmidt³ in *D. melanogaster*. Analogous variations have been found by Metz⁴ in species of *Sciara*. If the free ends of chromosomes are heterochromatic, we may be

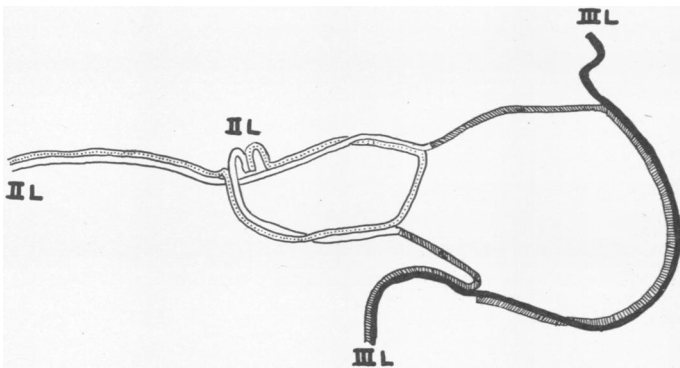


FIGURE 3

A scheme of the configuration shown in figure 2. The left limbs of the second and third chromosomes not involved in the translocations are shown white and black, respectively; those suffering translocation, dotted and cross-hatched, respectively.

dealing with real deficiencies of elements that are no longer essential constituents of the germ plasm. Or else, these may be cytological visible results of changes of the type of gene mutations. Such changes are, as well known, not usually reflected in the appearance of the chromosomes, but cytologically visible effects of gene mutations are theoretically not excluded. In any case, these variations seem to be terminal, although, of course, we cannot exclude the existence of an invisible telomere persisting at the end of the chromosome despite the visible variations.

* Visiting Professor at the University of São Paulo, working under the auspices of the Committee for InterAmerican Artistic and Intellectual Relations.

¹ Kikkawa, H., *Genetica*, 20, 458-516 (1938).

² Kaufmann, B. P., *Proc. Nat. Acad. Sci.*, 22, 591-594 (1936).

³ Goldschmidt, R., *Genetics*, 28 (1943).

⁴ Metz, C. W., *Carnegie Inst. Washington Publ.*, 501, 275-294 (1938).