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Ray C. Anderson
University of Minnesota

children until he has reached the latest known age of onset in the family, thirty-three. If at that age he has not developed ataxia, he can be reasonably certain (but not absolutely sure) that he will be free of the disease and that his children will not be ataxic. If he does develop the disease, however, he can know that some of his children are likely to become ataxic.

A person whose parents lived past the age of onset without becoming ataxic can assume that he will not be ataxic and that his children will not be ataxic.

The possibility of control of this disease by genetic means, then, rests upon the willingness of the children of ataxic members to cooperate.

This family can eliminate the ataxia from its descendants, provided the child of an ataxic parent is willing to wait until he has reached the age of thirty before he produces children. If he shows symptoms of the ataxia before or by that age, he should not, under the conditions, have children. However if he remains free of the defect at age thirty, his children probably will not be ataxic. The few exceptions to the rule, those with the onset of the disease occurring after thirty, will be only of slight importance in the general benefit to the family.

The late production of children may decrease the number of descendants for a few generations; but it does have the advantage that those who remain free of the disease will be relatively sure that their descendants will not be bothered with the disease.

THE INTERACTION OF CERTAIN GENES IN BRISTLE DEVELOPMENT OF *DROSOPHILA MELANOGASTER*

RAY C. ANDERSON
University of Minnesota

One of the foremost problems of modern genetics is the study of gene action, the manner in which genes affect developmental processes. We are all familiar with the adult phenotype of various mutants, both in *Drosophila* and in other experimental animals, but regarding their developmental behaviour we know comparatively little. Although physiological or developmental genetics, as this field is called, has a history of some twenty or thirty years, it has been only in the last ten years that workers have focussed much attention upon it. At the present time many geneticists and embryologists consider it one of the most promising fields for biological research, and in the words of Curt Stern[1] "the use of different genetic constitutions which pure genetics makes available as tools in the

[1] Stern, C., 1940. Recent work on the relation between genes and developmental processes. Growth Supplement 19–36.

study of development is perhaps at present the most fruitful link between the two aspects of biological phenomena, inheritance and development."

There are several general approaches possible in studying gene action in *Drosophila*. First, one may compare the development and expression of a single mutant gene with the normal. Waddington [2] did this with a score or more of wing mutants, describing the time and nature of deviations from normal wing development. Another method is to vary the environment under which development takes place, either by temperature or nutritional changes, or by transplantation work. This latter technique has been used by Beadle and Ephrussi [3] in their studies of eye color development. A third means of approach is the study of gene interaction, the effect of introducing a known gene into a certain genotype, a technique utilized by Neel [4] and many other workers.

The experiment dealt with in this paper concerns the interaction of several mutant genes of *Drosophila melanogaster*. Insofar as bristle mutants are very sensitive to environmental and genic changes, and since they may be measured quantitatively, one of them, Hairless H^{32y}, was chosen as the primary gene in the study. This gene, a dominant gene located on the third chromosome, expresses itself in a reduction of the number of large bristles normally present on the head and thorax of the adult fly, and also by a roughness of the eye, and a shortening of the fifth longitudinal vein of the wing. In addition to this Hairless gene, three modifying genes known as Minutes were used. These Minutes, which also are dominant genes, prolong larval development, reduce body and bristle size, and decrease viability and fertility. From his studies on Minute genes, Schultz [5] believed that they decreased the rates of various basic growth processes, and thus acted as limiting factors. In experiments carried out by other workers it has been shown that the addition of the Minute gene exaggerates the expression of the mutant character. Brehme [6] has shown that the imaginal discs, from which the hypodermis of the adult is formed, are less advanced in size and degree of differentiation in Minute larvae than in normal larvae of the same age.

Several Minutes were used: $M21^2$, on the second chromosome, which prolongs larval life approximately 12 hours; and M3w and

[2] Waddington, C., 1940. The Genetic control of wing development in *Drosophila*. J. Genetics 41: 75–137.

[3] Beadle, G., and Ephrussi, B., 1936. The differentiation of eye pigments in *Drosophila* as studied by transplantation. Genetics 21: 225–247.

[4] Neel, J., 1941. Studies on the interaction of mutations affecting the chaetae of *Drosophila melanogaster*. I The interaction of hairy, polychaetoid, and hairy wing. Genetics 26: 52–68.

[5] Schultz, J., 1929. The Minute reaction in the development of *Drosophila melanogaster*. Genetics 14: 366–419.

[6] Brehme, K., 1939. A study of the effect of development of Minute mutations in *Drosophila melanogaster*. Genetics 24: 131–161.

M3Fla, located on the third chromosome, and prolonging larval life approximately 41-43 hours.

To obtain the desired offspring, crosses were made between Hairless Moire females and the various Minute males. The females were aged 48 hours before being mated. Eggs were collected over a 36 hour period (12 hour intervals) by means of spoons (each containing 1-2 cc's of food) inserted into the mating vials. To prevent any crowding effects, only 110 eggs were placed in each culture bottle. The food used in all the bottles was prepared at the same time, to insure uniformity of culture conditions. Seven bottles were run for each of the three types of matings, and were kept at a constant temperature of 23 ± 1° C.

From each of the matings, four types of offspring were obtained: Hairless alone, Hairless in combination with Minute, Minute with Moire, and Moire alone. Twenty large head and thoracic bristles (three orbitals, two verticals, one ocellar, one postvertical, two humerals, one presutural, two notopleurals, two supraalars, two postalars, two dorsocentrals, and two scutellars) were checked for presence or absence, and mean bristle numbers computed on the basis of half flies.

Table 1 contains the mean bristle numbers in the various classes.

TABLE I. — MEAN BRISTLE NUMBERS PER HALF FLY

Genotype	Females		Males	
	N	Mean Bristle Number	N	Mean Bristle Number
H/+	60	12.80±.17	42	13.31±.19
H/M2	60	11.18±.21	60	10.88±.18
H/M3w	36	10.17±.23	52	10.33±.18
H/M3Fla	48	10.38±.22	40	10.10±.23
M2/Me	60	19.92±.03	60	19.93±.04
M3w/Me	50	19.82±.05	60	19.77±.06
M3Fla/Me	10	19.50 —	50	19.42±.10
Me/+	300	20.00 —	300	19.99±.005

The M2 gene appears to be less extreme in its modifying action than do the other two Minute genes. A significant difference is apparent between the mean bristle numbers for Hairless alone and for the Hairless-Minute combinations. There is also a significant difference between the Hairless-Minute 2 combination and the Hairless-Minute 3w and Hairless-Minute 3Fla combinations, but not between the Hairless-Minute 3w and Hairless-Minute 3Fla combinations.

In checking over these data, it is striking that those Minutes having the longest larval prolongation also have the greatest modifying effect on bristle expression. The many theories of bristle production in *Drosophila* proposed by Plunkett[7] and other workers

[7] Plunkett, C., 1926. The interaction of genetic and environmental factors in development. J. Exp. Zool. 46:181–244.

nearly always involve ideas of reactions, rates, and reacting substances. Any environmental or genic condition that would change these reaction rates or substances would then have a visible effect.

Plunkett[7] found that with an increase of temperature, there was a decrease in bristle number in the bristle mutant with which he worked. From this type of data, he postulated a bristle-destroying catalyst, whose rate of production would vary directly with the temperature. He then predicted that by using Minutes to prolong larval development the same reduction would occur, due to the increase in the duration of the reaction.

On the basis of mere prolongation it would be difficult to explain the modifying action of Minutes. M2, which prolongs larval life only 12 hours, causes a bristle reduction roughly 70% that of M3w and M3Fla, which prolong larval life about 42 hours. In this case it is advantageous to refer to the evidence presented recently by Brehme[8], who found that the larval prolongation of the various Minutes was qualitative, in that it occurred at different times during the larval instars. If this is true, then it seems quite logical to suggest that these qualitative differences may be responsible for the differences in modifying effect on developmental reactions. No strict proportionality would then exist for mere larval prolongation and bristle reduction.

It is difficult to ascertain the action of the Hairless gene, except that it upsets the normal balance of developmental reactions. There are three general possibilities: it may act by 1) reducing the amount of a bristle-favoring substance, 2) increasing the amount of a bristle-destructive substance, or 3) disturbing relative growth or differentiation rates.

From what is known of the embryology of *Drosophila,* it is possible to picture the sequence of events in the production of bristles as follows:

1. Formation of the imaginal discs from the ventral plate. Embryonic life.
2. Proliferation of these disc cells. Embryonic and early larval life.
3. Differentiation of these cells, involving the production of certain substances by either the disc cells or by other tissue cells vital to later bristle-forming capacities. Late larval life.
4. Proliferation of the disc cells to form the hypodermis of the adult. Early pupal life.
5. Development of certain hypodermal cells into trichogen, or bristle forming, cells, due to mechanical relationships. Pupal life.
6. Formation of the bristles as extensions of the trichogen cells. Pupal life.
7. Pigmentation of bristles. Pupal life.

[8] Brehme, K., 1941. Time relations during development of Minute larvae in *Drosophila melanogaster.* Genetics 26:141 (Abstract).

The Hairless gene might then be thought of as acting through a disturbance of the reactions involved in the reduction of cell isopotency during late larval life. The Minutes could then produce their effect by interfering with the time relationships of these reactions.

NOTES ON MALARIA-CARRYING MOSQUITOES OF NORTH-CENTRAL MINNESOTA

WILLIAM CHALGREN
University of Minnesota

ABSTRACT

The influx of 40,000 soldiers, many of them from the South, to Camp Ripley and the surrounding area during the summer maneuvers of 1940 raised the question of the possibility of malaria transmission by local species of mosquitoes and with this in mind a survey was undertaken by the State Department of Health.

The area surveyed extended from St. Cloud to Brainerd and from Lake Mille Lacs to Sauk Centre, and stations were set up at various places during successive weeks from June fifteenth to September fifteenth.

Three species of Anophelines, *maculipennis, punctipennis* and *walkeri* were found, in numbers far exceeding expectations. Two-thirds of possible adult resting places such as stables, privies, hog houses, etc. examined contained Anophelines, 95 percent of them being *maculipennis.*

Breeding areas were mapped and species preferences to certain habitats were noted. *Maculipennis* was again dominant as it was present in three-fourths of larval collections.

The significance of the races of *maculipennis* is briefly discussed.

THE DARTERS (ETHEOSTOMINAE) OF MINNESOTA

KENNETH D. CARLANDER
Minnesota Department of Conservation

It is surprising that the distribution of a group of fishes as interesting and common as the darters should be so little known. They are the most brightly-colored fishes found in Minnesota. Forbes and Richardson[1] say that the darters "are to the fishes of

[1] Forbes, S. A. and R. E. Richardson, 1920. The Fishes of Illinois State Natural History Laboratory.