The Investigation of the
Genetic Structure
of Populations

Progress Report

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by

Bruce Wallace

- ABSTRACT -

This report deals with a number of topics among which are the following:

(1) Gene control regions. A manuscript is appended which argues for the presence of a reverse repeat DNA segment following many, if not most, gene loci.

(2) Studies on the scute locus. Techniques are described by which crossovers in or very near the scute locus can be obtained selectively and, should any of these depart from the "normal" scute phenotype, by which the gametes produced by the abnormal male can be characterized in respect to the scute phenotype.

(3) The utilization of sugars by geographic strains of D. melanogaster. A survey of some 35 geographic strains of D. melanogaster and eight sugars (and other carbohydrates) has revealed a tremendous variation among the strains in respect to their ability to utilize (or not be inhibited by) these sugars.

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Appendices

- I. Gene control mechanisms and their possible bearing on
 neutralist-selectionist controversy (reprint)
- II. On inverted repeat sequences in chromosomal DNA

Gene Control Regions

Appended to this report is (1) a reprint of a paper that appeared in EVOLUTION (Wallace, B. 1975. Gene control mechanisms and their possible bearing on the neutralist-selectionist controversy. Evolution 29: 193-202) and (2) a manuscript entitled "On inverted repeat sequences in chromosomal DNA" by myself and T.L. Kass. The latter paper is scheduled to appear in GENETICS early in 1976.

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Studies on the scute locus in Drosophila melanogaster

Speculations by myself and Kass over the past few years concerning gene control regions has led to my undertaking a study of the scute locus in D. melanogaster. In brief, the Wallace-Kass model of gene control suggests that, in addition to a structural gene, the scute locus has an extensive control region containing (among others) a transcription initiation site (sensor) necessary for the production of bristles by certain cells. The mutations known as scute which lead to the absence of certain of the fly's bristles are mutations which also lead to the loss during embryonic development of this necessary sensor. Cells lacking this sensor are unable to produce bristles. The different patterns of missing bristles, under the model, can be ascribed to the differing positions of the sensor within the scute-locus control region of different mutant alleles, and the differing times during development at which the sensor is lost.

To collect data relevant to the Wallace-Kass model, it is necessary to study recombination within the scute locus. Because intra-locus recombinations occur with low frequency (reflecting the smallness of a single locus, not necessarily an inhibition of intra-locus recombination) the study

requires an efficient screening procedure. The procedure that has been chosen involves examination of the rare sons produced by females carrying two lethal-bearing scute chromosomes; in the one instance the lethal is (hopefully) to the left of the scute locus, in the other, to the right.

Data available from this proposed study are not extensive; the following sections outline various aspects of the study.

A. Characterizing scute males.

The mutant phenotypes of scute flies are not constant, even for flies carrying the same mutant allele. Precisely which bristles are missing depends upon both environmental and genetic factors. Therefore, the pattern of missing bristles on a single fly might tell very little about the "genetics" of scute for that one individual.

To obtain additional information about individual scute males, we mate them with attached-X females and plot the missing bristles of individual sons as shown on the right in Figure 1. The parental male is shown in the upper left corner of the worksheet; five sons are shown in the remaining drawings. Ordinarily, two worksheets are used for each parental male, thus allowing us to record eleven sons. Bristles that are missing from the various males are shown as solid circles.

The bristles on the head and thorax of the fly have been identified by number as shown in Figure 2. Consequently, it is possible to reproduce much of the information shown on the right hand side in Figure 1 in graphic form as has been done on the left side of that Figure. The bristles (left and right) which are missing from the parental male are shown by solid circles in the center column; the cumulative total number of missing bristles (again, both left and right) of the sons are shown as solid squares. Finally, the total number of sons examined are shown in the graph as dashed boundaries.

Figure 1

An example illustrating the construction of a progeny graph. The six outlines of flies on the right have been drawn on standardized work sheets. The bristles which are missing from the (parental) male to be tested are indicated by solid dots in the upper left of the six outlines. Those that are missing from sons obtained by mating the male with an attached-X female (five sons in the figure) are shown in the remaining five diagrams.

The graph on the left summarizes the information shown on the right. The bristles that are missing from the parental male are shown by solid circles in the central column. The cumulative number of bristles missing from his sons are shown as bar graphs. These bars reveal the nature of the gametes produced by the parental male in respect to the scute locus.

BRISTLE

-8-

EXAMPLE

Figure 2

The identification by number of the major bristles found on the head and thorax of D. melanogaster. Mutations known as scute (location 0.0 on the X-chromosome) "remove" certain of these bristles; different alleles of scute remove different sets of bristles.

The graph shown in Figure 1 does not yield information on individual sons. For example, among the five sons shown in Figure 1, one bristle #1 and one bristle #20 are present on the right. The graph does not tell us whether or not these bristles appeared on the same fly (they did not). Similarly, it does not tell us whether or not the "non-missing" bristles #19 and #20 were present on the same fly (they were not). Nevertheless, the bars in the graph provide what might be called the "phenotype" of the parental male's germ cells.

The graphic method for describing scute males was tested as a dry run on males obtained from a culture of scute-7 flies. The results were very interesting. The culture was found to be polymorphic for two distinct scute patterns (Figure 3 and 4): the A pattern in which head, scutellar, and thoracic bristles are missing, and the B pattern in which the missing bristles are limited almost exclusively to the scutellum.

Table 1 gives a summary of data that illustrate these two patterns. The flies, 1320 in all, that were examined in compiling these data were sons, grandsons, and great-grandsons of the males originally obtained from the stock culture, as well as those males themselves. Because all matings were to attached-X females, each pedigree involved only the single scute-bearing X-chromosome carried by the original male.

The two phenotypic patterns that were found in the scute-7 stock seem not to be unrelated. The progeny graph of a single fly (18-XI-VI) is illustrated in Figure 5. This fly whose father and grandfather were of pattern B was a mosaic; his right hand side was clearly of pattern A. His progeny, however, were typical of B; only the scutellar bristles were missing from his offspring.

Although the broad outlines of differences between patterns A and B

Figure 3

Progeny graph illustrating a pattern of missing bristles among the sons of male #20 which is known as pattern A. The pattern of bristles that were missing in male #20 himself is not identical to that shown among his progeny; nevertheless, the overall pattern is clearly distinct from that shown in Figure 4.

Figure 4

Progeny graph illustrating a pattern of missing bristles among the sons of male #9 which is known as pattern B. Notice that male #9 lacked bristles #5 but that this lack was not transmitted to his sons.

BRISTLE

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

-15-

PARENTAL
MALE

Table 1

Two distinct patterns of missing bristles found among male flies obtained from a scute-7 stock bottle. Pattern "A" was typical of males 6, 7, 16, 19, 20, and their male descendants obtained by mating with attached-X females; pattern "B" of males 3, 4, 5, 9, 11, 12, 14, 17, 18 and their descendants.

Bristle	Number and proportion of missing bristles			
	A		B	
	#	%	#	%
1	1177	99.1	1	0.1
2	1118	94.1	1	0.1
3	163	13.7	1	0.1
4	2	0.1	0	0
5	280	23.6	0	0
6	1180	99.3	1	0.1
7	1179	99.2	1	0.1
:				
15	602	50.7	0	0
16	12	1.0	20	1.4
17	6	0.5	31	2.1
18	1	0.1	0	0
19	1188	100.0	1157	79.7
20	1188	100.0	1347	92.8
Total possible	1188	-	1452	-
# flies examined	594	-	726	-

Figure 5

A progeny graph revealing that a male (18-XI-VI) that was mosaic for the two distinct missing-bristle patterns found in our stock of scute-7 possessed sperm of type B only. (Only the scutellar bristles are missing in pattern B.)

BRISTLE

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

PARENTAL
MALE

LEFT

RIGHT

are clear, minor variations nevertheless exist within these patterns. Figures 6 and 7 show the progeny graphs obtained from several sons of two different males. The three patterns of Figure 6 clearly differ from the two of Figure 7; still, variation within patterns A and B can be seen as well.

A final point about these preliminary tests concerns bristle #15: it is never missing in pattern B but it often is missing in pattern A. In fact, it is missing almost precisely one-half of the time.

If one-half of all males examined had two bristles #15 and one-half had none, the 50:50 pattern might be ascribed to a segregating autosomal modifier of scute. This is not the case, however; much of the 50:50 pattern arises from males lacking one or the other of two bristles. Data bearing on this point are given in Table 2. In many instances, whether sons lack zero, one, or two bristles #15 seems to be determined entirely by chance (1:1:1:1 ratio); in others, there are clear symmetrical excesses of sons lacking none or both bristles. These data are not yet understood; suffice it to say that any off-on mechanism (transcribe-not transcribe, for example) would generate a 50:50 ratio just as would gene segregation. Furthermore, an off-on switch in respect to transcription could operate through intra-strand recombination involving reverse repeat segments of DNA because such recombination rotates a segment of DNA so that any asymmetrical or directional process is reversed.

B. Obtaining yellow-lethal, scute-bearing schromosomes.

One class of lethal-bearing scute chromosomes required for the screening technique demands a lethal mutation to the left of the scute locus. To get such chromosomes, we have used the procedure illustrated in Figure 8.

Figure 6

Progeny graphs of three males (20-V, 20-VII, and 20-IX) each of whom carries a scute-bearing X-chromosome transmitted by their father (#20) in a mating with an attached-X female. The bar graphs reveal the type of micro-variation that occurs in the inheritance of scute.

Figure 7

Progeny graphs of two males (9-I and 9-IX), each of whom carries a scute-bearing X-chromosome transmitted by their father (#9) in a mating with an attached-X female. The bar graphs reveal the type of micro-variation that occurs in the inheritance of scute.

9.1X

Table 2

Relation between the phenotype of fathers in respect to bristle #15 and that of their sons who carry identical X-chromosomes. Open circle, bristle present; solid circle, bristle absent. The two circles illustrate the left- and right-hand bristles.

Father	Sons	Pedigree					Total
		6	7	16	19	20	
00	00	11	7	15	22	34	89
	●●	2	3	14	3	9	31
	●●	16	5	10	7	18	56
	●●	9	17	16	4	10	56
●●	00	3	14	2	-	1	20
	●●	4	6	5	-	0	15
	●●	5	8	1	-	1	15
	●●	5	11	3	-	4	23
●●	00	6	7	1	2	13	29
	●●	6	2	4	0	5	17
	●●	7	2	1	4	4	18
	●●	8	16	5	5	13	47
●●	00	15	17	1	6	10	49
	●●	6	7	2	3	7	25
	●●	6	10	3	6	10	35
	●●	18	15	5	5	26	69

Figure 8

Mating scheme that yields scute-chromosomes that also have mutations at the yellow locus as well as lethal mutations that are in some way associated with yellow. The precise nature of each lethal mutation is not revealed under this mating scheme.

Figure 8

To obtain "yellow - lethal" - scute chromosomes:

The initial cross involves irradiated (or formaldehyde treated) scute males which are mated to homozygous yellow-apricot females. This cross would normally produce wildtype daughters or, through rare non-disjunction, yellow-apricot females. Yellow-non-apricot females, however, reveal mutations induced at the yellow locus of the irradiated scute chromosome. This chromosome is isolated, checked to see that it is also lethal to males (the lethality is not necessarily to be attributed to the mutation at the yellow locus) and it is then maintained as a yellow-lethal scute stock. Five yellow-lethals have been found on scute chromosomes among tests of 57,770 x-rayed chromosomes (none among 35,779 formaldehyde treated ones).

C. Obtaining scute-Notch chromosomes.

The second class of lethal-bearing scute chromosomes needed for screening cross-overs in (or near) the scute locus are scute-Notch chromosomes. The technique is illustrated in Figure 9. Scute males are irradiated and mated with homozygous Muller-5 (w^aB/w^aB or "basc") females. The progeny females are examined for the presence of Notched wings. Females suspected of carrying newly induced Notch mutations are mated with Muller-5 males. If half of the female offspring are Notch and if no scute males appear in the progeny, the scute chromosome is assumed to carry a new Notch mutation. Thirteen Notch mutations have been obtained by irradiation of scute chromosomes.

D. Screening for cross-overs in the scute region.

Screening for cross-overs in the scute region requires still another special chromosome -- a Y-chromosome that bears a small region of the X including the Notch (wildtype) locus. Males carrying this $Y-N^+$ chromosome are mated with scute-Notch females; scute-Notch sons that would otherwise die are obtained from this cross. These males are mated with Yellow-lethal-scute females; among their daughters are females

Figure 9

Mating scheme that yields scute-chromosomes that also have mutations at the Notch locus. The precise nature of the Notch mutations is not revealed under the mating scheme.

Figure 9

To obtain scute-Notch chromosomes:

carrying two lethal X-chromosomes. These females are to be crossed with Muller-5 (basc) males in an effort to obtain rare sons carrying (of necessity) recombinant X-chromosomes (Figure 10).

In a hurried preliminary test in which the fathers in the final cross carried the special $Y-N^+$ chromosome (thus eliminating the screening aspect of this cross), 32 males were obtained (25 wildtype, 7 lacking only a single bristle) which seemed as if they might carry cross-over X-chromosomes that affected the scute locus. These males were mated with attached-X females in order to characterize their gametes as far as scute is concerned (as shown in Figure 1). From these crosses, 356 females but no males were obtained. The precise meaning of this result is not clear at the moment; it would seem that these chromosomes still retained the Notch mutation. Why, then, they did not exhibit the ordinary scute phenotype is unclear.

Studies on laboratory islands

The study of laboratory islands has been terminated. Much of the raw data has been transcribed onto key punch pads and punched into the cards themselves. Two analyses of these data are planned: (1) changing patterns of association of the 18 Drosophila species in individual vials and (2) the outcomes of competition between 2, 3, and 4 Drosophila species that happen to enter the same vial. Both analyses will require computer analysis of existing data.

Hard and Soft Selection

A reprint of an article (Wallace, B. 1975. Hard and soft selection revisited. *Evolution* 29: 465-473) is appended to this report.

Figure 10

Mating scheme that yields females possessing two lethal-bearing scute-chromosomes (one lethal associated with yellow to the left of scute, the other with Notch to the right). Among the progeny of these females, the only viable males would be those carrying recombinant X-chromosomes.

Figure 10

To screen for cross-overs within the scute locus:

Only males carrying chromosomes in which a cross-over has occurred between (y-1) and N can survive.

A fair proportion of these chromosomes should involve crossing over within the scute locus.

Temperature gradient experiments

Experiments on the behavioral preferences of individual Drosophila species on a temperature gradient and the outcome of competition between different Drosophila species on the gradient are being carried out by James Fogelman, a graduate student studying for his Ph.D.

The utilization of sugars by different strains of D. melanogaster.

Quite by accident it has been discovered that extensive differences exist between different geographic strains of D. melanogaster in respect to their sensitivity to or ability to utilize various sugars. An experiment that was designed to reveal whether strains of flies would eventually adapt to a single sugar if that served as their major carbon source for an extended period revealed differences between strains but differences, it turned out on closer examination, that existed before the start of the experiment. The observed differences could be traced to the geographic strains, themselves.

During the past year a survey involving more than 35 strains of flies and eight different sugars (and related substances) or none at all has been carried out. The results are given in Table 3.

The geographic strains are worldwide in origin: BER, Bermuda; BOG, Bogota, Colombia; BS, barcelona, Spain; BV, Blacksburg, Virginia; CA, Capetown, Africa; CO, Commack, N.Y.; EV, Ellensville, N.Y.; KSA, South Africa; MO, Monroe Co., N.Y.; MWA, Madeira; NO, New Orleans; PVM, Madeira; PYR, the Pyrenees; QI, Israel; RVC, Riverside, Calif.; SC, Santago, Chile; VAG, Athens, Greece, and various localities along the Eastern coast of the United States (1-11).

Table 3

Summary of the average number of adult progeny produced per vial on sugar-brewer's yeast media. The "sugar" in each test was as shown or was omitted from the medium ("none"). Propionic acid and chloramphenicol were added to the medium to inhibit the growth of microorganisms.

LOCALITY STRAIN	GLUCOSE	SUCROSE	MANNOSE	MANNITOL	DEXTRIN	XYLOSE	GALACTOSE	LACTOSE	NONE	AVERAGE
BER 1	21	5	14	8	6	0**	48*	2**	29*	15
BGC 3	24	27	75*	18	5	11	14	3**	4**	20
BS 1	5	7	22*	14	8	7	-	0**	9	9
BS 2	52	66*	48	59*	18	15	0**	8	27	33
BV 1	7	20*	6	6	4	1**	4	8	5	7
CA 1	13	26	66*	8	0**	2	3	0**	0**	13
CO 3	12	9	19	19	2	1**	11*	1**	2	11
EV -	63	55	49	42	44	38	-	67*	23	48
KSA 2	49	50	84*	31	137*	24	2**	1**	16	44
KSA 4	-	-	65	-	-	-	-	-	-	65
MO 12	13	35*	17	9	17	1**	30*	0**	1**	14
MWA 3	-	19	29	36*	2	2	29	3	8	16
NO 2	-	12	2	6	6	1	6	4	11	6
PVM -	15	67*	67*	15	5	20	12	-	17	27
PYR 3	57	53	78*	51	70*	10	34	5	24	43
QI 2	6	25	15	41*	24	2	24	0**	1**	15
RVC 2	28	13	27	6	29	25	5	32	3	19
RVC 4	39	34	28	46*	19	8	28	3	8	24
SC 1	2	13	36*	9	0**	6	-	11	0**	10
SC 2	-	-	43	-	-	-	4	-	-	24
VAG 2	17	54*	33	19	4	1**	2	0**	6	15
VAG 3	12	26	33*	13	13	6	25	10	4	16
1 A	47	41	35	29	40	19	2	13	25	28
1 B	3	35*	21	8	2	12	2	3	4	10
2 C	12	46	74*	6	3	1**	3	9	4	17
3 D	49	42	26	43	32	7	44	7	21	30
3 A	-	-	49	25	-	-	72*	0**	-	37
4 C	34	24	21	41	21	4	44	6	28	25
4 B	23	26	37	34	41*	12	6	17	2	22
5 B	1**	14	19	3	40*	7	25	0**	1**	12
8 D	30	46	54	23	36	37	4	27	27	31
9 A	6	52*	101*	17	43	7	21	0**	6	28
10 A	3	13	-	31*	0**	10	8	1**	4	9
10 D	16	12	35	43*	15	1**	6	21	6	17
10 E	10	67*	76*	10	7	10	0**	3	11	21
11 A	31	30	42	39	27	11	24	24	8	26
11 C	24	22	-	-	29	7	56*	11	20	24
AVERAGE	23	32	41	24	22	10	19	9	11	22

*exceptionally high number of progeny

**exceptionally low number of progeny

The individual entries in Table 3 are average progeny sizes of 3 vials (occasionally of 2) which generally contained 7-12 non-virgin parental females. The three vials of individual tests are uniform in their progeny yields as a rule so that the differences among the entries in the table are highly significant.

It is remarkable that those sugars which support melanogaster larvae poorly do not do so uniformly. Thus, seven strains listed under "xylose" are designated as yielding exceptionally low numbers of progeny; nevertheless, three or four strains yielded 24 or more flies. Three strains seemed unable to utilize Dextrin; KSA-2, however, yielded an average of 137 flies per vial on that starch -- the highest average in the table.

Upon examining individual strains, we find that EV grows well on all sugars tested. CO-3, however, does poorly on most "exotic" sugars except galactose on which it does well. KSA-2, though able to do well on dextrin, does poorly on both galactose and lactose. A number of strains (BER-1, CO-3, MD-12, and others) do poorly on lactose but not on galactose.

Preliminary tests reveal that the inability to utilize xylose and lactose are recessive but are not necessarily the result of single genes. Standard genetic tests are proceeding.

Miscellaneous studies

As usual a number of ancillary experiments have been carried out; some of these, we hope, will grow into important future studies.

A. Phyps populations.

Three populations have been established in plastic cages (four additional ones are kept in standard culture bottles) the parental flies of

which were orange (eye color) D. persimilis and incomplete (wing vein), hooked (bristles), jaunty (wings) D. pseudoobscura. The wildtype hybrid females were backcrossed to the mutant males of both sorts (F_1 pseudoobscura-persimilis hybrid males are sterile) and a backcross generation of both types was obtained. The backcross flies were placed in a population cage where, in the course of several generations, the mutant genes (orange, incomplete, hooked, and jaunty) were eliminated. The resulting wildtype population must, therefore, carry genes of both species; in the field, such a population would be classified as "introgressive."

Three Phyps populations have been set up in cages. Phyps-1 is maintained on conventional instant *Drosophila* medium; phyps-2 is maintained on excessively watery (essentially a liquid) medium; phyps-3 is maintained on instant medium that is made using a 0.1% formaldehyde solution.

The purposes of these populations are several. The watery and formaldehyde-containing media are used merely to force populations of flies carrying artificial, introgressive combinations of genes from two distinct species to adapt to unusual environments. In addition to these obvious pressures, however, are the inherent ones involving courtship, mating, and reproduction. Each phyps population must, from the two mating rituals that lead to the pronounced sexual isolation of D. pseudoobscura and D. persimilis, settle upon its own courtship and mating procedure. Males and females in these populations that recognize each other rapidly will be the ones which leave the most progeny.

Preliminary data suggest that phyps-1 has a mating behavior which resembles that of D. persimilis. It remains to be seen whether each phyps population has arrived at this solution, whether some will have mating behaviors resembling D. pseudoobscura, or whether unique mating

behaviors will be developed in these isolated laboratory populations.

Subsequently, utilizing the imposed selection for watery or formaldehyde-containing media and the "natural" selection for the modification of mating behavior, population cages will be set up in which phyps and either persimilis or pseudoobscura flies will be compelled to coexist. Such cages may lead to the development of sexual isolation in the laboratory.

B. NaCl, CuSO₄, and (NaCl + CuSO₄) populations.

Populations of D. melanogaster have been established in which the instant medium is prepared with a NaCl solution or one containing CuSO₄. The population maintained on NaCl is genetically marked with the fast allele at the Acph-1 locus; that on CuSO₄ with the slow allele of that locus.

The purpose of these cages is to follow the development of resistance to NaCl or CuSO₄ as it develops in these populations. More importantly they are intended to reveal the development of reproductive isolation between samples of these two populations of a single species when these are used to start the populations that are maintained on both NaCl- and CuSO₄-containing medium.

These populations have not yet yielded information.

C. The "artificial crab".

This experiment was inspired by the three known instances in each of which a Drosophila species has become a commensal living with and upon land crabs. Land crabs have nephric ducts that open just below their eye stalks. The wastes from these ducts pass behind platelike appendages which cover a rough, bristly area of exo-skeleton below the eyes; eventually, the liquid wastes drain into the mouth. The entire system serves to conserve

water. In the passage of these wastes over the numerous bristles, bacteria and other microorganisms break down nitrogenous waste material. It is on this decaying and fermenting material that the commensual Drosophila larvae live.

The details of its construction need not be given here. A cage was built, however, in which dilute urine dripped onto the astroturf of a leucite-astroturf-lucite "sandwich." The astroturf was initially inoculated with soil microorganisms.

Of the dozen or more Drosophila species exposed to this "artificial crab," only D. virilis maintained itself successfully. After some nine months, an accumulation of empty pupal cases and urine-salts made the "crab" uninhabitable. A sample of a dozen or more flies were removed and transferred to a bottle containing standard culture medium in an effort to save the selected strain of D. virilis. Although these flies laid hundreds of eggs, and although a great many tiny larvae could be seen on the food and on the sides of the glass culture bottle, only six or so adults survived to emerge on standard medium. These were placed in the "crab" once more but they also died.

A new version of the crab is needed, one that permits the replacement of a waste-contaminated "astroturf-sandwich" by a fresh one. This experiment will be taken up once more, however, only when two or three specimens of land crabs have been obtained from the Florida Keys. These crabs are easily kept in terraria, I understand.

D. Coldroom-1 populations.

Reports, many via the seminar route, have recently stressed the role of pigmentation of snails and beetles, for example, in heat absorption and the enhanced physical activity of darkly pigmented forms in cold but

sunlit areas. A population of D. melanogaster was set up to test these claims experimentally. The population of wildtype flies is maintained in a 17° room with a blower fan circulating the cold air through the population cage. Attached to the lid of this cage, however, is an electric heater that is on for eight hours each day. The heater reaches a temperature of 60° or more.

Within a period of about six months, the flies in this population have become more heavily pigmented than any other population of D. melanogaster I know. If flies from population coldroom-1 and the wildtype stocks that were used in starting it are etherized and placed side by side on a white milkglass counting plate, it is obvious to all that the flies from coldroom-1 are considerably darker than the parental stocks. Presumably, the greater activity of dark flies at 17° under infrared radiation is sufficient to result in a natural selection for dark pigmentation.

It is my belief that a similar selection would occur in an overheated population in the presence of a cold black body. If this can be shown experimentally, it will suggest a biological basis for dark pigmentation among primitive human beings inhabiting a tropical rain forest.

Proportion of Principal Investigator's Time Devoted to Research Under this Contract:

Well over 30%