MUTATIONS IN THREE SPECIES OF DROSOPHILA

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INTRODUCTION

In a preliminary paper (METZ and METZ 1915), two mutations were recorded in *Drosophila tripunctata* Loew., and an undescribed species called "species B." Since that paper was written *D. tripunctata* has been discarded because of its poor breeding qualities, and has been replaced by another species, *Drosophila obscura* Fall., which, together with "species B," has been bred in large numbers during the last eighteen months. In both of these species mutations have occurred within this time. *D. obscura* has given rise to at least three, and "species B" to at least twelve. In addition, an eye color mutant has been found in a third species that was collected for cytological purposes and not bred extensively. Considering all four species together, nineteen mutants have appeared in our cultures.

The most interesting of the mutants, at the present time, are the twelve in "species B,"—or, as I may now call it, *Drosophila virilis* Sturtevant MSS.[1]—because in this species at least three groups of linked factors have already been obtained and it seems probable that more will be evident when all of the twelve factors are tested out. Thus far only

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[1] This species is soon to be described by Dr. STURTEVANT, to whom I am indebted for permission to use his manuscript name.

six have been fully tested. Three of these are sex-linked, two others are non-sex-linked and linked together, and the sixth is neither sex-linked nor linked to either of the others. In a subsequent paper I hope to report more fully upon the linkage phenomena when additional factors are studied, and shall here confine myself mainly to a description of the various mutant characters and a brief account of their inheritance.[2]

MUTANTS IN *DROSOPHILA VIRILIS* STURTEVANT MSS.

Normal specimens of this species are dull brown in color with dark red eyes and slightly shaded wings. The males have no sex combs and neither sex has any color pattern on the body save four faint, dark stripes running longitudinally on the dorsal part of the thorax. The mutants, in the order of their appearance, are as follows:

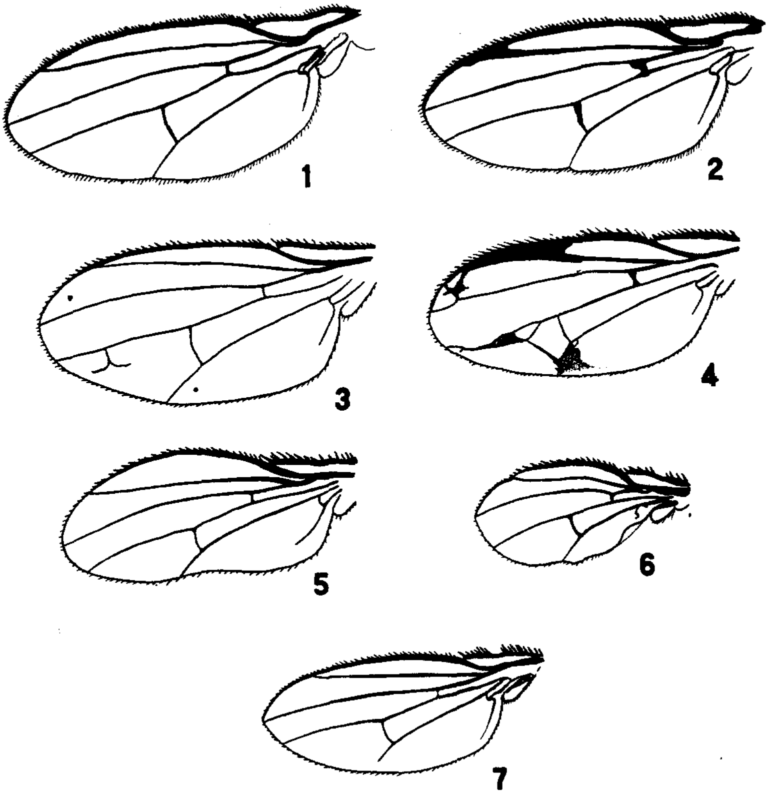

Figure 1. Normal wing of *Drosophila virilis* Sturtevant MSS. Figure 2. Confluent wing. Figure 3. Axillary wing. Figure 4. Confluent axillary wing. Figures 5 and 6. Two types of concave wing. Figure 7. Acute wing.

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[2] I am indebted to my wife for making the accompanying drawings, and for other assistance during the course of the work. Acknowledgment is also due to Mr. JOSEPH KRAFKA for aid in the breeding work.

Confluent (figure 2). Non-sex-linked, dominant; wing veins modified. This was described in a previous paper (METZ and METZ 1915).

Axillary (figure 3). Non-sex-linked. Wing veins modified by accessory veins or branches, mostly in the apical half or near the inner margin of the wing; a variable character.

Concave (figures 5 and 6). Non-sex-linked recessive. Wing shape and size modified; one or both wings concave instead of convex on the inner margin, or else reduced in size; hairs on arista curled instead of straight.

Morula. Non-sex-linked recessive. Ommatidia of the eye irregularly crowded together instead of symmetrically arranged in rows.

Yellow. Sex-linked recessive. Entire fly yellow instead of dark brown.

Acute (figure 7). Non-sex-linked recessive. Wing shape and size modified; wings much shorter and narrower than normal, and pointed instead of rounded at the apex; the fifth vein frequently not reaching the margin; anterior pair of orbital bristles often absent.

Steel. Non-sex-linked recessive. An iridescent, metallic, steel-colored spot in the center of the eye.

Bald. Non-sex-linked dominant. Bristles around the ocelli, and frequently the ocelli also, reduced or absent.

Black. Non-sex-linked recessive. Body, legs and wings black instead of dark brown; especially noticeable in the wings.

Glazed. Sex-linked recessive. Eyes with a varnished appearance as if freshly coated with shellac, and with the ommatidia greatly disarranged.

Magenta. Sex-linked recessive. Eye color dark purplish red or magenta, instead of the normal red.

Forked. Sex-linked recessive. Bristles of the head and thorax aborted, twisted and forked, giving a singed appearance.

ORIGIN AND GENETIC BEHAVIOR OF MUTANTS

The first mutant to appear in my cultures of *virilis* was confluent, which arose in July or August, 1914. Its origin and behavior have been described in a previous paper (METZ and METZ 1915), and it is only necessary here to add some further data in support of the conclusion previously expressed, that confluent when present in duplex ("double dose") has a lethal effect. This conclusion was based upon the fact that no homozygous confluent flies could be obtained, and that heterozygous flies when inbred give a ratio of two confluents to one normal, instead of the expected 3 : 1. Subsequent experiments have borne out this conclusion in every way. Not a single homozygous fly has been found

Table 1 a

Confluent by normal.

Culture number	Normal	Confluent
2033	132	110
2122	13	10
2127	10	9
2138	43	36
2148	10	15
2150	45	37
2151	61	42
2156	39	14
2159	50	77
2160	32	26
2170	26	38
2171	19	10
2176	34	30
2178	14	12
2183	29	26
2184	27	12
2185	12	23
2186	14	16
2187	73	47
2201	22	12
2203	28	27
2217	62	47
Total	795	676

Table 1 b

Confluent by confluent, from confluent by confluent.

Culture number	Normal	Confluent
1327	21	36
2025	29	50
2024	73	98
2026	43	58
2027	19	23
2028	31	90
2030	44	73
2032	14	36
2048	58	99
2050	33	40
2061	45	61
2105	13	20
2106	8	13
2107	3	7
2108	17	36
2109	32	46
2110	23	63
2111	24	41
2112	20	51
2158	19	47
Total	569	988

Table 1 c

Confluent by confluent from confluent by normal.

Culture number	Normal	Confluent
1341	51	74
2072	11	17
2168	20	30
2169	20	26
2174	6	19
V269	52	88
V272	17	23
V277	23	55
V278	16	20
V286	45	76
Total	261	428

among the hundreds I have tested during the two years (over thirty generations) since this mutant appeared. And the ratios have consistently been such as to indicate the absence of the homozygous class in matings of confluent by confluent. Some of these results taken at random from my records are shown in table 1. Three types of matings are given here for comparison: (a) confluent by normal, (b) confluent by confluent, in which the parents are derived from confluent by confluent matings, and (c) confluent by confluent, in which the parents are derived from confluent by normal. According to expectation some of the matings in (a) and (b) should give only confluent offspring while in (c) they should all give three confluents to one normal. In reality no pair has given a purely confluent family; and the ratios in (c) are approximately 2 : 1 instead of 3 : 1. Furthermore the ratios in (b) are just like those in (c), indicating that the parents are alike (heterozygous) in both cases, and that no homozygous flies have appeared. Only one alternative to this explanation occurs to me,—namely, that homozygous flies are produced, but are sterile. This however is made very improbable by the fact that practically all of the confluent flies breed readily and may be tested by mating in pairs.

The second mutant character, axillary, appeared in a normal mass culture during September, 1915. It presents many irregularities both in its manifestations and in its genetic behavior. In pure stock it may vary from a condition in which several extra veins and branches are present in each wing, to one in which only the slightest trace of a branch or extra vein may be seen; or it may be entirely lacking in a portion of the flies. In behavior axillary is usually an irregular recessive, but frequently it shows itself to a slight extent in a few heterozygous individuals. These features are brought out by the data in table 2. It is not improbable that axillary depends upon, or is decidedly influenced by, several factors, most of which I have not yet located. Certainly it is greatly affected by at least one factor other than the axillary factor

TABLE 2 a
Axillary by normal.

Culture number	Axillary	Normal
1378	26	77
2173	19	60
2200	10	66
Total	55	203

TABLE 2 b
Axillary by axillary.

Culture number	Axillary	Normal
2075	10	6
2195	31	29
2212	16	0
Total	57	44

itself. This factor is confluent. When in the presence of confluent, axillary, instead of behaving as a recessive, becomes an almost complete dominant. This is shown in table 3. When axillary flies are mated to normals they give from five to twenty-five percent of axillary in F_1, and when axillary flies are inbred (pure stock) they give about fifty or sixty percent axillary; but when axillary flies are mated to confluent, or confluent axillary (heterozygous) to normal (it makes no difference which way the cross is made) the percentage of axillary is greatly increased and nearly all of the axillary flies are in the confluent class. Furthermore nearly all of these confluent axillary flies show a greatly exaggerated effect of both confluent and axillary, (compare figures 2 and 3 with figure 4). This peculiar interaction of factors is similar in a general way to many found in *Drosophila ampelophila* and other organisms, except that in the latter, so far as I know, dominance and

TABLE 3 a

Confluent by axillary.

Culture number	Confluent axillary	Normal	Confluent	Axillary
2127	6	9	3	1
2170	28	18	10	8
Total	34	27	13	9

TABLE 3 b

Confluent axillary (heterozygous) by normal.

Culture number	Confluent axillary	Normal	Confluent	Axillary
2148	8	10	7	0
2150	22	45	15	0
2151	30	60	12	1
2159	34	77	16	0
2171	4	19	6	0
2176	23	27	7	7
2178	5	12	7	2
2185	13	12	10	0
2186	12	14	4	0
2201	5	22	7	0
2202	2	18	3	0
2203	17	28	10	0
2217	31	60	3	1
2296	18	35	8	1
Total	224	439	115	12

recessiveness are not affected (see MORGAN, STURTEVANT, MULLER and BRIDGES 1915, p. 45).

Among the other six non-sex-linked characters five (concave, morula, acute, steel and black) are simple recessives and were each observed in several individuals at their initial appearance. Concave arose in a normal stock culture during September 1915. One concave female from this culture, when mated to normal brothers, gave 64 normal and 17 concave offspring, from which the present stock is descended. Until very recently concave has been looked upon as a variable character, easily affected by the environment, because the characteristic (wing shape) used to distinguish it, was not at all regular in appearance (figures 5 and 6). But I have just discovered that the curled hairs on the arista provide a constant and easily recognizable diagnostic character that will make future experiments relatively simple.

The history of morula is much like the early history of concave. Five morula flies of both sexes appeared in a mass culture and gave rise to the strain now in use. Like axillary, morula sometimes fails to exhibit itself even in homozygous flies, and the ratios are correspondingly distorted (table 4).

TABLE 4

Morula by morula, pure stock.

Culture number	Morula	Normal
1352	52	7
1355	13	0
1356	41	46
1371	130	0
2040	102	25
2044	38	3
2047	14	34
2054	31	1
V11	101	0
V19	6	0
V61	29	5
V69	106	0
V83	48	25
Total	711	146

The character acute appeared in concave stock some time in the early spring of 1916, and was at first thought to be a modification of concave; but when the constancy of this particular type was noticed it was separated from concave and has subsequently bred true.[3] Aside from the fact that its viability is unusually low it is a typical recessive character.

At about the same time that acute was discovered the eye color mutant steel appeared (February 1916) in a normal stock that had been kept separated from other stocks for several months. Until very recently this character, like concave, was thought to be greatly affected by cultural conditions, but it now appears that exposure to the air, especially warm air, after removal from the moist culture bottle, brings out the character and makes it possible to distinguish a large proportion of the steel individuals.

The mutant black appeared during May 1916 among the offspring of two separate pairs of flies, both derived from a single preceding culture (an axillary by morula cross). In both cases the ratio (approximately 3 : 1) indicates that the parents were heterozygous, and makes it probable that one of the grandparents was pure black. Two black females and one black male from one of the two pairs (number V151) when inbred gave in F_1 ten black offspring and a large number of black-colored pupae that failed to hatch. The ten flies that did hatch were mated together and likewise produced a large number of larvae and pupae but only a few flies, all of which were black. Another culture of three flies, from this same bottle (V151) gave a large number of black flies with abnormal abdomens. These when inbred gave much the same result as the preceding, most of them producing only a few flies from among many pupae. One pair of black flies from the other original bottle (V141) showed a lower degree of mortality among its progeny. It produced 54 offspring (all black) in F_1, and two pairs of these gave 24 offspring in F_2. But stock bottles made up from this are now showing a high degree of mortality similar to that in the other line. Apparently, then, the black factor has a partial lethal effect, or else a lethal factor of some sort is associated with it. Possibly the abnormal abdomen, found in many of the black flies, is an independent character and responsible for the mortality. If so, matings now being made ought to separate the two and give a viable black stock.

The remaining non-sex-linked character, bald, made its appearance in a confluent culture during January 1916. The exact count was not obtained from this bottle, but subsequent breeding has shown bald to be a dominant character, completely or very closely linked with confluent. Unlike confluent, however, it does not always exhibit itself, and the

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[3] Other morphological types of concave, such as those shown in figures 5 and 6 have likewise been tested, but are apparently all due to a single factor.

bald class in nearly all matings is unduly small because some of the genetically bald flies appear normal. These features will be considered further under the heading of linkage.

It now remains to consider the four sex-linked characters yellow, glazed, magenta and forked. Yellow has appeared upon two occasions, first (July 1915) in a single male that died without breeding, and second (January 1916) in several males within one mass culture. These latter were successfully bred and gave rise to the present yellow stock. Yellow is a perfectly clear-cut character, breeding absolutely true, and showing typical sex-linkage. Its only peculiarity is its low viability, making it somewhat difficult to breed in pairs. When the original yellow males were mated to normal females they gave in F_1 only normal offspring, and in F_2 165 normal females, 85 normal males and 79 yellow males. When yellow males were mated to heterozygous females they gave normal males and females and yellow males and females in approximately equal numbers. Similarly yellow females mated to normal males gave normal females and yellow males in equal numbers (537 : 544).[4] Additional records involving yellow are given in the section on linkage.

Glazed is a character of recent origin (June 1916) and has not yet been studied extensively. It appeared in one male individual in a mass culture containing steel and normal. When bred to normal-eyed females this male gave in F_1 normal males and females, and in F_2 164 normal females, 85 normal males and 44 glazed males. The F_2 females proved to be of two kinds, as expected,—one homozygous for normal eye, the other heterozygous for glazed. Mated to a normal brother one of the latter gave 36 normal-eyed females, 18 normal-eyed males and 11 glazed males. Another, mated to a glazed male, gave 11 normal females, 17 glazed females, 16 normal males and 9 glazed males.

During the same month in which glazed appeared (June 1916) the character magenta was also found. It arose in acute stock, one pair of which gave 38 normal females, 19 normal males and 17 magenta males. No record was made of the eye color of the parents or grandparents in this case, but it is very probable that the mutation arose with the female used in this mating. Some of the original magenta males were mated to normal females, and others to yellow females. The former gave in F_1 only normal offspring, and in F_2 90 normal females, 43 normal males and 40 magenta males. The latter are considered in the next section

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[4] One of these matings gave, in addition, two yellow females and one normal male, apparently due to contamination or non-disjunction.

under linkage. In addition, a number of the normal sisters of the original magenta males were mated to normals, and several gave magenta males in F_1 showing that they were heterozygous for the magenta factor.

The other sex-linked character, forked, appeared in a single male individual (June 1916) from a mating between confluent males and a normal female. When mated to normal females it gave in F_1 only normal offspring, and in F_2 610 normal females, 270 normal males, and 185 forked males. Like most of the other mutants it is less viable than normal, with the result that the mutant class falls below the expected proportion.

LINKAGE

Among the above twelve characters three of the sex-linked and three of the non-sex-linked ones have been tested for linkage. The non-sex-linked characters are confluent, bald, and axillary, of which confluent and bald are closely linked together, while axillary shows no linkage with either. As has been previously noted, bald made its appearance in confluent stock. The bald confluent flies were mated to normals, and *inter se,* with the results shown in table 5. At first it appeared that crossing over took place in one direction, since some of the confluent flies in nearly every case had normal bristles on the head. But when these flies were tested by mating to unrelated normals they all gave bald offspring, showing that the apparent crossovers were due to the failure of bald to exhibit itself. A dozen or more flies were tested in this way and all gave the same results. It will also be noticed that in the table three flies are recorded in the normal wing bald class. These are flies in which one of the four bristles around the ocelli was gone, but the loss of a bristle was evidently purely accidental, for the flies proved to be genetically normal when tested by breeding. Up to the present time no known crossovers have occurred between these two factors.

The results of confluent by axillary matings have already been given in a previous section (table 3), and I need only note here the absence of linkage in this cross. The first four records, and probably several of the others given in table 3, are from matings in which the confluent axillary parents received confluent and axillary from opposite sides, and should, if the characters were linked, give the effects of repulsion, i. e., confluent and axillary should appear mostly in different individuals, seldom in the same individual. Actually, however, the confluent axillary class is larger than the two others combined. Only the assumption of

TABLE 5

Confluent bald (heterozygous) by normal, or inter se, in pairs.

Culture number	Normal head normal wing	Normal head confluent	Bald normal wing	Bald confluent
V133	41	0	1	30
V140	47	22	1	71
V142	36	2	1	52
V143	6	8	0	7
V146	24	2	0	19
V149	33	2	0	36
V167	17	1	0	22
V181	7	0	0	9
V204	15	0	0	14
V206	32	6	0	17
V207	31	14	0	9
V209	33	29	0	13
V210	40	6	0	22
V211	31	24	0	14
V212	41	16	0	15
V220	14	1	0	16
V221	28	5	0	24
V222	34	8	0	15
V223	33	3	0	23
V224	26	6	0	11
V237	50	15	0	11
V242	20	11	0	16
V243	7	3	0	8
V244	25	4	0	10
V247	29	9	0	23
V249	34	11	0	11
V267	21	2	0	15
Total	755	210	3	533

very loose linkage, together with crossing over in both sexes, could explain such a result upon the basis of linkage; and since crossing over in the male has not been demonstrated in this species the assumption is very improbable.

In the group of sex-linked characters it has been possible to ascertain linkage values more rapidly than in the other groups, and three factors have already been located approximately. Or rather, two of them have been located with respect to a third. In both cases the linkage value is low, and the proportion of crossing over high. The first characters tested were yellow and glazed. Unfortunately only two cultures were made up from this cross and the numbers are very small, but in each case the crossover class is so large as to leave no doubt that the linkage is very loose.

The other characters are yellow and magenta. Males of the latter bred to females of the former gave in F_1 normal females and yellow males. The females bred to normal males gave normal females, and four classes of males in the proportion of 70 brown (body) red (eye), 155 brown magenta, 118 yellow red, and 89 yellow magenta. In this case, as in the former, the linkage is evidently loose, but here it is determined with greater accuracy and the percentage of crossing over may be said to be approximately 36. Or, in the terminology adopted for *Drosophila ampelophila,* yellow and magenta are about 36 units apart.

Knowing the approximate linkage between yellow and glazed, and between yellow and magenta, it may now be predicted that if the factors compose a linear series in this species as they do in *ampelophila* the linkage between glazed and magenta will prove to be either relatively close, if they are both on the same side of yellow, or practically indistinguishable if they are on opposite sides.

COMPARISON BETWEEN MUTANTS IN *D. VIRILIS* AND *D. AMPELOPHILA*

Before turning to the mutants in other species it may be well to consider the relations between those just described and the known mutants in *Drosophila ampelophila.* Some of these relations have been mentioned in an earlier note (METZ 1916) but may be treated more fully here. The first and most striking feature is the apparent correspondence between some of the mutants found in *virilis* and those already known in *ampelophila.* The three characters, confluent, yellow and forked, for instance, are so similar to characters of the same name in *ampelophila* as to suggest at once that they are actual duplicates. In the case of confluent we have three different criteria that point to a correspondence in the two species. First the morphological characteristics, which are practically identical, second the fact that the character is dominant in both cases, and third that it has a lethal effect when the fly is homozygous for it (see BRIDGES 1916). The latter statement must be modified somewhat with respect to *ampelophila,* for confluent flies in that species show a very low viability and many fail to breed. It is possible, therefore, that some of these are homozygous. Likewise the number of offspring produced by confluent flies is so small as to make the ratios questionable; but so far as they go they resemble those in *virilis.* Through the kindness of Professor

MORGAN I secured, some time ago, a stock of confluent *ampelophila* and endeavored to test it out with respect to its lethal effect. The results, from the few pairs that could be induced to breed, are given in table 6. Most of the confluent flies used as parents in these crosses were from confluent by confluent matings and theoretically one third of them should be homozygous. Actually, among the ten flies that bred, only one pair gave purely confluent offspring. Apparently one member at least of this pair was homozygous, unless the result was accidental. Unfortunately no F_2 flies were secured to make certain of the constitution of the F_1, and the evidence is not very conclusive.

TABLE 6

Confluent ampelophila.

a. *Confluent by normal in pairs.*

Culture number	Normal	Confluent
1278	19	13
1285	33	15
1286	45	33
1290	25	24
Total	122	85

b. *Confluent by confluent in pairs.*

Culture number	Normal	Confluent
1288	4	7
1289	2	9
1279	0	27
Total	6	43

These data are meager, but when taken together, and in connection with the fact that in *ampelophila,* as in *virilis,* no homozygous stock of confluent has been secured, it seems probable that the lethal effects as well as other features are similar in both species.

Turning to the two characters yellow and forked, it is to be noted especially that they are both sex-linked in each species. Yellow is slightly darker in *virilis* than in *ampelophila* (see MORGAN 1912), but since the normal *virilis* is much darker than *ampelophila* this is to be expected if the factors really correspond. In the case of forked the morphological correspondence is complete even to the smallest detail, so far as I can tell from a careful comparison of the flies side by side.

So far as the evidence goes, then, it strongly suggests that the factors for confluent, forked and yellow in *virilis* are actually homologous to those in *ampelophila.* If this is true it follows, as indeed might be expected, that the germ plasms of the two species bear a definite structural resemblance to one another which we may hope to analyze experimentally. Furthermore, if these factors are really homologous, the fact that yellow and forked are sex-linked in each species would indicate that the structural relations of the germ plasm so far as the factorial arrangement is concerned are alike or similar in the two species. And if this is the case it is difficult to avoid the conclusion that there is a genetic continuity of germinal structures—in all probability chromosomes—in these flies.

When the linkage relations between these respective factors are known the evidence will be much more definite; but even if the linkage values are not the same in the two species it does not necessarily mean that the organization is different, for the amount of crossing over might be very different in different species. The crucial test will be to determine whether a linear series similar to that in *ampelophila* is present in *virilis.*

MUTATIONS IN *DROSOPHILA OBSCURA* FALL.

My studies upon *Drosophila obscura* are still in their initial stages and may be passed over with a brief description of the three mutants at hand. The first is characterized by the presence of from one to four extra bristles on the scutellum. It was first observed in October 1915 when several extra bristle flies of both sexes appeared in a mass culture. Subsequent matings have shown it to be a non-sex-linked recessive, but one which is very dependent upon environmental conditions for its manifestation. Table 7 illustrates a typical series of results obtained from homozygous flies mated in pairs. As will be noted some of the pairs give nearly 100 percent of extra bristle offspring, while others give a very much lower percentage. No systematic attempt has been made to determine the agent responsible for these deviations, but it has been noted that in almost every case the higher percentages of extra bristle flies are found in well fed, moist cultures, and the lower percentages in poorly fed, dry cultures.

In the second mutant, triangle, the posterior cross vein forks and forms a triangle at its junction with the fourth vein. This character appeared during February 1916 among the offspring of two separate pairs of flies from a single preceding culture. One of the pairs gave 15 triangle and about 75 normal offspring. The other gave 7 triangle and several normals (exact number not recorded). Two matings of

TABLE 7

Drosophila obscura, extra bristle stock inbred in pairs.

Culture number	Extra bristle	Normal
2191	17	8
021	20	75
022	18	120
029	21	60
030	34	30
031	24	91
032	28	29
033	39	115
034	50	103
037	24	33
038	3	33
040	11	80
041	11	19
049	11	39
051	58	6
052	16	10
057	17	1
061	21	3
Total	423	855

triangle by triangle from these gave respectively 66 triangle: 5 (questionable) normal and 19 triangle: 3 normal. In each case some of the females may have mated with normal males before the cultures were made up,—a fact that may account for the normals in their progeny. Judging from these preliminary data it seems probable that the character will prove to be a simple, true-breeding recessive.

The third mutant is characterized by abnormally short veins in the wing. Both the fourth and fifth veins fail to reach the margin, and occasionally the posterior cross vein is broken. The character is a sex-linked recessive. It appeared during July 1916 in nine males from a mass culture containing extra bristle flies. These males, bred to normal females, gave in F_1 normal males and females, and in F_2 81 normal females, 38 normal males and 38 short vein males. No F_3 flies have been obtained yet, but the character appears to be regular in its behavior.

AN EYE COLOR MUTANT IN *DROSOPHILA SIMILIS* WILL.

Most of the mutants in *Drosophila ampelophila* and in the species just considered, have arisen in more or less highly inbred stock, and it is consequently of interest to note any that have not. Several have already been recorded (HYDE 1915 a, STURTEVANT 1915), and the following is an additional one. It is distinguished by the possession of chocolate-colored eyes instead of bright red eyes. Flies having this eye color appeared in either the first or second generation of descendants from a normal wild female of *Drosophila similis* that I collected in Cuba. Since the species has never before been bred in captivity there is little chance that inbreeding could have had anything to do with the origin of the mutant in my cultures. The following is a brief history of the character in respect to its origin and behavior: Progeny of a single wild female were transferred without examination, to stock bottles. One of these bottles, examined after the next generation appeared, contained approximately equal numbers of chocolate and red-eyed flies. Three normal females from this, mated to chocolate males, gave 8 chocolate and 7 normal offspring. Five other normal females mated to five chocolate males gave 37 chocolate and 35 normal offspring. Four mass cultures of chocolate flies bred true and gave nothing but chocolate-eyed progeny, (more than 100), as did succeeding cultures of pure stock.

MUTABILITY IN DIFFERENT SPECIES OF DROSOPHILA

In conclusion a word may be said concerning the individual mutative tendencies of the different species of Drosophila thus far studied. The rapid appearance and varied characteristics of mutations in *Drosophila ampelophila* have given rise to the natural impression that this species possesses a peculiar tendency to mutate, not shared by even its close relatives. It is not at all surprising that this opinion has arisen, considering the extraordinary number of mutations obtained from *ampelophila,* but in view of the recent mutations in some of the other species it becomes much less probable that the mutating capacity is peculiar to the one fly. Mutations have now been recorded in six other species,—two in *repleta* (HYDE 1915 a, STURTEVANT 1915), one in *confusa* (HYDE 1915 b), one in *tripunctata* (METZ and METZ 1915), twelve in *virilis* (present paper), three in *obscura* (present paper), and one in *similis* (present paper). These leave no doubt that species other than *ampelophila* have at least some capacity for mutating. Whether this is true of all Drosophilas is, of course, a question, but the fact that mutations have appeared in nearly all the species studied extensively, and in some studied only superficially, tends strongly toward an affirmative answer. In a like manner the evidence furnished by *virilis* and *obscura* tends to modify the conclusions respecting the relative rapidity of mutation in the various species. Of course it is impossible to get more than a rough estimate of the total number of flies examined in any of these species, but since my cultures of *virilis* alone have given rise to at least a dozen mutations within the last year[5] there can be little question that this species mutates approximately as fast as does *ampelophila*. And in *obscura* the rate can not be greatly different, for here three mutations have already been found among a relatively small number of flies examined.

Taking all of these facts together it seems not improbable that most, if not all, Drosophilas are essentially alike in respect to their tendency to mutate, and that a series of mutations could be found in any of them if sufficiently large numbers of individuals were examined.

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[5] Two new ones have appeared since the first part of this paper was written.

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