

A SEX DIFFERENCE IN LINKAGE INTENSITY
OF THREE AUTOSOMAL FACTORS
IN THE DOMESTIC PIGEON¹

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DURING a study of color inheritance in the domestic pigeon three autosomal factors have been found to be linked. In a preliminary report (HOLLANDER 1936) certain statements were made which must be modified in the light of additional data.

Previous authors have failed to demonstrate any autosomal linkages in the pigeon. CHRISTIE and WRIEDT (1923) attempted to show a linkage between white-tail and saddle or shield pattern, but the characters were not proved simple and the numbers were too small for significance. Crossing-over between sex-linked factors has been reported by COLE and KELLEY (1919), CHRISTIE and WRIEDT (1925), STEELE (1931), and HAWKINS (1931).

JONES (1922) gave results of ten backcross matings involving the segregation of black (*S*) and checker (*C*); the characters are both dominant to the wild type or "blue bar." From the ten matings 73 offspring were obtained; of them, 41 lacked *S*. Since the *S* factor is epistatic to *C*, only these 41 can be utilized in estimating a possible linkage. A review of the ancestry of the heterozygotes used in the matings has shown that all are in the coupling phase. There appears to be a suggestion of linkage: female heterozygotes produced six checker and 13 bar progeny, and males nine checker and 13 bar.

The same factors have been used in the present study. In addition, the T-pattern, a dominant allele of checker (*C*^T) and a third factor, "opal" color (*o*) have been included (HOLLANDER 1938).

A few other color factors have occasionally come into the tests. These are *B*^A (ash, sex-linked); *b* (chocolate, a recessive allele of *B*^A); *d* (dilution, sex-linked); *e* (recessive red); *G* (grizzle); *Od* (dominant opal, not an allele of *o*); *Of* (faded); and *sy* (smoky). The combinations of the color factors which were encountered were seldom confusing. However, epistasis of ash, dilution, and recessive red over opal, and of recessive red over *S* and *C*, necessitated leaving a few birds unclassified, except when further breeding tests have revealed their constitution (HOLLANDER 1938). The results may be summarized as follows:

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REGION	MALE HETEROZYGOTES			FEMALE HETEROZYGOTES		
	NON-CROSS-OVERS	CROSS-OVERS	% CROSS-OVERS	NON-CROSS-OVERS	CROSS-OVERS	% CROSS-OVERS
$S-C(C^T)$	28	23	45.1 ± 7.0	83	13	13.5 ± 3.5
$S-o$	19	23	54.8 ± 7.5	102	19	15.7 ± 3.3
$C(C^T)-o$	99	7	6.6 ± 2.4	251	6	$2.3 \pm .9$

Male heterozygotes have given definite evidence for linkage only in the case of C with o , while females show definite linkage in each test. The figures are so significant that we are driven to conclude that a sex difference in crossing over exists.

Three-point tests have also been made. Analysis into the component two-point data is summarized as follows:

REGION	MALE HETEROZYGOTES			FEMALE HETEROZYGOTES		
	NON-CROSS-OVERS	CROSS-OVERS	% CROSS-OVERS	NON-CROSS-OVERS	CROSS-OVERS	% CROSS-OVERS
$S-C(C^T)$	29	21	42.0 ± 7.0	57	12	17.4 ± 4.6
$S-o$	49	38	43.7 ± 5.3	100	25	20.0 ± 3.6
$C(C^T)-o$	43	4	8.5 ± 4.1	67	2	2.9 ± 2.0

These values are very similar to those from the two-point tests. When all the data are combined, values are obtained as follows:

$S-C(C^T)$	57	44	43.6 ± 4.9	140	25	15.2 ± 2.8
$S-o$	68	61	47.3 ± 4.4	202	44	17.9 ± 2.4
$C(C^T)-o$	142	11	7.2 ± 2.1	318	8	$2.5 \pm .9$

The factorial order indicated by the above values is S, C, o , although the difference between $S-o$ and $S-C$ is so small that it is not in itself statistically significant. However, there is another basis for assuming the same order. In the three-point tests one crossover class was contributed to only by male heterozygotes; this probable double crossover class also indicates the factorial order S, C, o .

In figure 1 chromosome maps based on the order assumed and utilizing the total crossover frequencies for $S-C$ and $C-o$, separately for each sex of heterozygote, are shown. It is quite likely that the actual map distances shown are too short in the region $S-C$, because of double crossing over,

but the positions of the factors can only be marked approximately at best.²

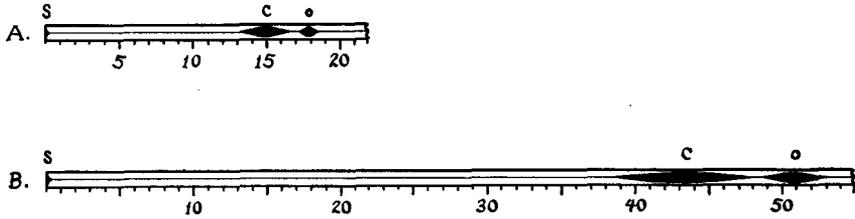


FIGURE 1. Sketches of the probable order and map distances, A. from female heterozygotes, and B. from males.

DISCUSSION

The high rate of embryonic death in many of the matings of male heterozygotes deserves comment. The high crossover percentages in males cannot be explained by differential mortality since opal females, also involved in such matings, have been found to give eggs of poor hatchability much more frequently than other females, no matter what type of male is used (HOLLANDER 1938).

From the linkage data it is clear that in the case of this autosome, female heterozygotes show between one-fourth and one-third as much crossing over as males. Whether this is true for the other autosomes is as yet unknown; in other organisms which have been investigated, the chromosomes are fairly consistent with each other in this respect.

The pigeon might be expected to resemble the fowl in its sex difference of linkage intensity, but such is not the case according to data at present available. The male fowl has slightly less crossing over than the female (WARREN and HUTT 1936). *Drosophila* ordinarily shows no crossing over in the male, while the silkworm moth is reported to have none in the female (STURTEVANT 1915). Mice and rats show somewhat less crossing over in males than in females (GATES 1931). The pigeon then seems to stand alone among animals whose linkage phenomena have been studied in its marked reduction of crossing over in the female.

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² Tables of detailed data have been deposited in the editorial office of *GENETICS* and may be consulted by anyone interested.

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