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SHORT PAPERS

Genetic evidence of an unorthodox chromosomal system in the lac insect *Kerria lacca* (Kerr)

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SUMMARY

The colour difference (crimson and yellow) in *Kerria lacca* (Kerr) was used to test the 'Lecanoid' system of chromosome behaviour proposed on cytological evidence. The colour strains bred true for colour. Reciprocal matings between the colour strains produced only crimson sons and daughters, confirming that the colour difference is not sex-linked and that the male is somatically a diploid. The phenotypes of the F_2 and the backcross generations differed according to the heterozygosity and the direction of cross of the F_1 parents, since heterozygous females produced two kinds of gamete but heterozygous males produced only the maternal kind. Thus, while elimination of the paternal gene and hence chromosome was confirmed during the formation of male sex-cells, demonstration of somatic diploidy of the male is not compatible with a 'Lecanoid' system in *K. lacca*. Instead, the available cytogenetic evidence is suggestive of a chromosome system with heterochromatization and elimination of the paternal chromosome-set confined to the male germ line.

Coccids have provided a wealth of cytological information revealing a variety of unusual systems (Hughes-Schrader, 1948; Bennett & Brown, 1958; Brown, 1965). The lac insect *Kerria lacca* (Kerr) (Syn. *Laccifer lacca* Kerr), being an economically useful coccid because of its resinous secretion—the lac of commerce—has also received considerable attention, although the cytological picture remains somewhat confused due to contrary reports on its chromosome number and behaviour (Tulsyan, 1963; Dikshith, 1964*a*, *b*). The research reported here was undertaken to obtain genetic evidence to test the unorthodox 'Lecanoid' system proposed by Dikshith (1964*a*).

MATERIALS AND METHODS

Earlier investigations of the author (1967) showed that the colour difference (crimson and yellow) in *K. lacca* is inherited as a unit character and that crimson is dominant to yellow. The progeny phenotypes in the F_1, F_2 and backcross generations could thus be used to test the proposed unusual system. Ten or more progenies were scored from each class of mating.

The insects used in these experiments originated from long-maintained laboratory stocks of true breeding crimson and yellow strains of lac insects. The test insects were reared on potted plants of *Moghania macrophylla* under cover of 80 mesh wire-net to check the ingress of insects from outside. The progeny was scored at sexual maturity since the colour genes produce their visible effects after the lac larvae have grown for some time on the host plant (Chauhan, 1967).

RESULTS

Table 1 shows the progeny phenotypes in crosses of crimson and yellow stocks of lac insects.

These results show that the colour strains used in this study were homozygous for the type. Reciprocal matings between the colour strains produced only crimson sons and daughters, confirming that the colour difference is not sex-linked and that the male is somatically a diploid.

Table 1. *Progeny phenotypes in crosses of crimson* (Y) *and yellow* (y) *stocks of lac insects*

Generation	Genotype of Mother	Genotype of Father	Number of progenies	Daughters Crimson	Daughters Yellow	Sons Crimson	Sons Yellow
Parent	*YY*	*YY*	11	1003	0	467	0
	yy	*yy*	10	0	607	0	367
F_1	*YY*	*yy*	12	1099	0	617	0
	yy	*YY*	14	979	0	407	0
F_2	*Y*(*y*)	*Y*(*y*)	10	991	0	579	0
	y(*Y*)	*y*(*Y*)	11	401	332	212	137
Backcross	*y*(*y*)	*y*(*Y*)	14	0	907	0	391
	y(*y*)	*Y*(*y*)	10	891	0	516	0
	y(*Y*)	*y*(*y*)	11	498	676	281	217
	Y(*y*)	*y*(*y*)	14	527	508	346	231

The allele contributed by the father is shown in parentheses.

The F_2 data demonstrate that the classical Mendelian inheritance was not obtained in *K. lacca*. The phenotype of the F_2 generation differed according to the direction of cross of the F_1 parents. Thus, while yellow females mated to crimson males produced the two colour forms in the F_2 generation, this segregation was completely absent in the reciprocal cross. One sex in the F_1 generation was, therefore, suspected of producing only one kind of gamete.

The F_1 males and females (from reciprocal matings) when test-crossed to the yellow mates confirmed that while heterozygous females produced two kinds of gamete, heterozygous males produced only the maternal kind since they produced exclusively either the yellow or the crimson progeny depending upon whether they had the yellow or the crimson mother. The elimination of the paternal gene, and hence chromosome, during the formation of male sex-cells was therefore confirmed. This also explains the unusual F_2 results.

In the segregating progenies, the proportion of crimson and yellow insects deviated significantly from the expected ratio of 1:1. Earlier tests (N. S. Chauhan, unpublished) had indicated a reduced viability of the yellow insects. This is also reflected in the present tests except in one of the backcross progenies, which shows an excess of yellow daughters, and for which no explanation can be offered at present.

DISCUSSION

The demonstration of an unorthodox inheritance in *K. lacca* rules out a normal chromosome behaviour as would be indicated on Tulsyan's (1963) evidence.

The 'Lecanoid' system, as unravelled in the mealy bug, refers to a unique genetic system in which the paternal chromosome-set becomes heterochromatic during early embryogeny of the male, is then maintained as a genetically inert component during development and is finally discarded during the formation of sex-cells, so that the male expresses and transmits only the maternally derived genes (Hughes-Schrader, 1948; Brown & Nelson-Rees, 1961; Nelson-Rees, 1962; Brown & Nur, 1964; Brown, 1966). More recent evidence has suggested that the heterochromatic chromosomes may become deheterochromatized, regaining genetic activity, in certain tissues (Nur, 1967); but as yet no genetic loci are known for which the paternally derived allele has an effect in the male (Brown & Nur, 1964; Brown, 1969; Brown & Wiegmann, 1969).

While elimination of the paternal chromosomes is now confirmed for *K. lacca*, the identical phenotypes of reciprocal F_1 males clearly demonstrate that both paternal and maternal chromosomes are somatically active. This is incompatible with Dikshith's (1964*a*) claim that one haploid set of chromosomes in *K. lacca* males is heterochromatic (and, by implication, inactivated) from an early embryonic stage, i.e. that *K. lacca* has the 'Lecanoid' system. In fact, although Dikshith makes this claim, his actual observations relate only to spermatogenesis. In discussing the literature on other species he appears to confuse two quite distinct situations: (1) heterochromatization (and inactivation) of the paternal chromosomes in somatic tissues, and their elimination in spermatogenesis—the 'Lecanoid' system, as in the mealy bug *Planococcus citri* (Brown & Nelson-Rees, 1961; and others); (2) male haploidy by elimination of the paternal chromosomes in embryogenesis, as in the scale insect *Pseudaulacaspis pentagona* (Bennett & Brown, 1958). The situation in *K. lacca* appears to be different from either of these.

In conclusion it may be stated that in males of *K. lacca* the paternal chromosome-set is genetically active in (at least some) somatic tissues, but that it is not transmitted through the sperm. A similar situation has been shown to occur in a dipterous species (Gallun & Hatchett, 1969). This evidence together with Dikshith's (1964*a*, *b*) demonstration that one haploid set of chromosomes is in the heterochromatic state and is eliminated in spermatogenesis are suggestive of a chromosome system in which heterochromatization and elimination of the paternal chromosome-set is confined to the male germ line. Brown (1969) while referring to his unpublished work has also reported that in one group of coccids, the Aclerdidae, heterochromatization is confined to the germ line. Nevertheless, the evidence against the 'Lecanoid' system is not conclusive. It is possible that, as suggested by Nur (1967) for the mealy bug, the paternal chromosomes are deheterochromatized and genetically reactivated in certain tissues. If this were the case, the yellow locus of *K. lacca* would be the first known instance of such reactivation in a 'Lecanoid' system. A precise understanding of the system involved will thus have to await further cytogenetic analyses in lac insects.

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