proved in biting midge producing areas in artificial canal banks with this equipment, and the equipment is suitable for distribution of any insecticide which can be mixed with sea water.

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GENETIC FITNESS OF THE MUTANT, CARMINE EYE, IN *CULEX TARSALIS* IN THE LABORATORY[1]

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ABSTRACT. Experiments designed to test the effect of the eye-color mutant, *car*, on mating competitiveness indicated *car* does not significantly influence mating ability. Estimates of survivorship to pupae indicate that *car* might be an overdominant gene. However, the genetic history of the stocks used indicated that a general hybrid vigor was expected and might have produced the overdominance detected.

INTRODUCTION

The development of chromosomal translocations for the genetic control of the mosquito, *Culex tarsalis*, has progressed in our laboratory to a point where assessment of the relative genetic fitness of the translocation lines is necessary. Recently visible genetic markers were incorporated into translocations generated in this species (McDonald et al. 1978). This allowed the development of selection experiments which depend upon genetic markers to assess the results. Before assessing the fitness of translocations, the fitness of populations that carry genetic markers should be determined.

Carmine-eye color (*car*) (Asman 1975b) was chosen for the first round of selection experiments because *car* can be detected in the larval, pupal, and young adult stages. This report is an assessment of the mating competitiveness of *car*-bearing adult males against wildtypes and the survivorship of *car* to the pupal stage.

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METHODS

Three different mating trials were carried out for each of 2 different stocks. In the first series, Chico wildtype males competed against *car* heterozygote males for *car* heterozygote females. In the second series, wildtype males competed against *car* homozygote males for *car* heterozygote females. In the third series, wildtype males competed against *car* homozygote males for *car* homozygote females. Except in 2 cases, replicates consisted of 100 wildtype males, 100 males bearing carmine genes and 100 females bearing carmine genes. (The exceptions are noted in the tables.) All mating trials were initiated with 3 and 4 day-old virgin adults.

Replicates were housed in large laboratory cages measuring 45 cm wide, 60 cm long, and 60 cm tall except 1 replicate which used a cage 120 cm tall. Each cage was kept in an incubator maintained at 24°C. Large open water pans were placed in the incubators to maintain high humidity. A light cycle was provided by 14 hr of high intensity light from a fluorescent bulb, and an additional 1½ hr of artificial dawn and dusk were provided daily by a 4 watt incandescent bulb. Sugar cubes and water were continually available in each cage. Restrained mice were placed in the cages for only 1 or 2 nights to provide blood meals, and this minimized multiple oviposition by females. Egg rafts were collected daily, isolated into vials, and allowed to hatch. First-instar larvae from rafts with 50 or more hatched eggs were scored for carmine-colored ocelli. The scoring procedure was preceded by a short exposure to strong light which developed the darker wildtype pigment to avoid misclassifying all larvae as *car* types.

The parentage of each raft could be determined uniquely from the eye color of progeny. All progeny of wildtype fathers have wildtype phenotypes. The progeny of *car*/ + males mated to *car*/ + females have a phenotype ratio of 3 + to 1 *car*. Those of *car* fathers have progeny entirely *car* or an equal mixture of *car* and wildtype phenotypes, depending on the female genotype used in the experiment.

Systematic classification errors could result from multiple insemination; however, multiple insemination is rare in this species (Asman 1975a). Three mosquito stocks were used in these experiments: Chico wildtype, Old carmine, and New carmine. Old carmine stock was maintained with small effective population sizes since the initial isolation of *car* by Asman (1975b). New *car* was produced by outcrossing Old carmine to Chico stock and recovering *car* in the progeny.

Relative survivorship to the pupal stage was determined for *car* heterozygotes and *car* homozygotes by rearing test-cross progeny. Relative survivorship to the pupal stage of wildtype and *car* was determined from F_2 hybrid-cross progeny. In this case the expected number of *car* heterozygotes was subtracted from the total number of wildtype pupae so the ratio of wildtype to homozygous *car* could be determined. Rafts produced by the mating trials provided the appropriate progeny. Rafts with low hatch or few *car* phenotypes were discarded. The remaining rafts were diluted to a density of approximately 3 rafts per pan, and reared according to ordinary laboratory procedures. Pupae were removed from the culture and scored for eye color.

RESULTS AND DISCUSSION

The results of the first series of mating trials in which wildtype males and *car* heterozygote males competed for *car* heterozygote females are summarized in Table 1. The fraction of rafts fathered by *car* heterozygote males varied from 38 to 72% in 5 replicates. The average fraction was 57%.

Results of the second series of mating trials in which wildtype males competed against homozygous *car* males for *car* heterozygote females are summarized in Table 2. The fraction of rafts fathered by *car* males varied from 48 to 66%. The overall fraction was 53%. Note that the

Table 1. Mating competitiveness of wildtype males with heterozygous *car* males for heterozygous *car* females.

(Old carmine stock)				
Total adult ♀♀	Total rafts	Progeny *car*	Progeny only +	% Families with *car*
100	32	16	16	50
100	36	26	10	72
100	19	12	7	63
100	16	10	6	63
100	24	9	15	38
Totals	127	73	54	57

Table 2. Mating competitiveness of wildtype males with *car* males for heterozygous *car* females.

(New carmine stock)				
Total adult ♀♀	Total rafts	Progeny *car*	Progeny only +	% Families with *car*
100	59	39	20	66
100	75	36	39	48
120*	85	42	43	49
Totals	219	117	102	53

* Test cage was 120 cm tall.

Table 3. Mating competitiveness of wildtype males with homozygous *car* males for homozygous *car* females.

Total adult ♀♀	Total rafts	Progeny *car*	Progeny only +	% Families with *car*
100	76	34	42	45
80	63	30	33	48
100	45	20	25	44
100	20	11	9	55
100*	81	44	37	54
Totals**	204	95	109	47%

* New carmine stock.
** Sum of trials using old carmine stock.

replicate carried out in the largest cage (120 cm tall) yielded 85 rafts of which 49% were fathered by New carmine males. In the third series of mating trials, wildtype males competed against homozygous *car* males for *car* females (Table 3). In 4 replicates using Old carmine males the fraction of the rafts fathered by *car* males ranged from 44 to 55%. The overall fraction for Old carmine males was 47%. For the 1 replicate using New carmine males, the fraction of rafts fathered by *car* males was 54%.

None of the mating trials detected significant deviations from equal competitiveness at a significance level of 5%. Carmine heterozygote males showed a tendency to be favored over wildtypes. It is likely that a generalized hybrid vigor was responsible for this observed tendency. All data indicate that the *car* mutation had little if any effect on mating competitiveness.

Of the 892 testcross progeny in tests relating to survivorship to pupae, 403 were *car* and 489 were *car* heterozygotes. Since equal numbers were expected, there was a significant selection favoring *car* heterozygotes relative to *car* homozygotes (Chi square = 8.3, $p < .01$). The estimate of the fitness of *car* homozygotes relative to *car* heterozygotes is 403/489 = 0.824.

Of the 1,884 F_2 hybrid-cross progeny scored, 424, or 22.5% were *car* homozygotes. Assuming that wildtype homozygotes were not selected relative to *car* heterozygotes, the number of wildtype homozygotes was 1460/3 = 487. Thus significant selection also acted against *car* homozygotes. It was possible to estimate the relative fitness of wildtypes from the available data using the method of Crow and Kimura (1970). Given 424 *car/car* pupae and the relative fitness of *car/car* to *car*/ + of 0.824, the expected number of *car*/ + pupae was 2 X 424/0.824 = 1,029. The expected number of +/+ under the assumption that +/+ were not selected relative to heterozygotes was half the number of *car*/+ which was 515 in this case. Subtracting the estimated number of *car*/+ from the total number of wildtype phenotypes yielded 431 +/+ pupae if we relax the assumption of no selection against +/+. The relative fitness of +/+ was 431/515 = 0.84. This result corresponded to nearly symmetrical overdominant selection. Since the car-

mine stock was only outcrossed once to Chico, it seems likely that this was the result of generalized hybrid vigor rather than overdominance at the *car* locus.

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INITIAL STUDIES ON THE GENETICS OF *AEDES SIERRENSIS*

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ABSTRACT. Basic cytogenetic information and the genetics of red eye (*r*), a recessive mutation in *Aedes sierrensis*, are briefly discussed in relation to a current sterile-male control program.

INTRODUCTION

Aedes sierrensis (Ludlow), the western North American treehole mosquito, is one of the most annoying biting pests in recreational areas of the foothill and tree-stanced residential areas of California (Bohart and Washino 1978). Currently the species is incriminated as a vector of canine heartworm in several Northern California counties. Weinmann and Garcia (1974) experimentally infected female *Ae. sierrensis* with *Dirofilaria immitis*.

Ae. sierrensis is recorded from 52 of the 58 California counties (Loomis et al. 1956), and is widely distributed in other western states. The species breeds in individual treeholes wherever wooded areas are found. The adults are day-time flyers, and the females feed on a range of warm-blooded animals including man. According to Carpenter and LaCasse (1955) males congregate outside of treeholes and around warm-blooded animals where they wait for females.

The species is a possible candidate for the sterile-male control method because of its unique ecology and the difficulties involved in the application of chemicals for its control. A program was initiated in 1977 (Terwedow and Asman) to determine the feasibility of using males sterilized by irradiation for genetic control, and subsequent tests in laboratory and large outdoor cage trials gave encouraging results (Anderson et al. 1979).

Genetic information on this species is essential as a basic tool for ecological as well as additional genetic studies. This paper deals with the basic cytogenetics of wild type *Ae. sierrensis*, and the genetics of

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