RED-EYE, A SEX-LINKED MUTANT IN THE MOSQUITO *ERETMAPODITES QUINQUEVITTATUS* THEOBALD[1]

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ABSTRACT. A recessive, sex-linked mutant is described in *Eretmapodites quinquevittatus*. The mutant, red-eye (*re*), exhibits complete penetrance and can be determined in the larvae, pupae, and adults of both males and females. Testcross data place *re* approximately 17 map units from the sex locus (*m*) on linkage group I. Sex determination in *Er. quinquevittatus* is similar to that of other culicine mosquitoes (*m/m* = female, *M/m* = male).

INTRODUCTION

The genus *Eretmapodites* of the family Culicidae is confined to the Ethiopian region and Madagascar (Gillett 1972). The genus is divided into at least 34 species and 4 subspecies (Stone et al. 1959, Stone 1961, 1963, 1967, 1970). Only two species, *Er. chrysogaster* (Gillett 1958) and *Er. quinquevittatus* (Hartberg and Gerberg 1971) have been successfully colonized in the laboratory. Most diagnostic characteristics of this genus are the same as those of the *Aedes* and the form of the genitalia suggests some affinity with the subgenera *Stegomyia* and *Aedimorphus* (Edwards 1941).

Eretmapodites species have been reported to be good laboratory vectors of yellow fever (Bauer 1928) and Chikungunya (Gilotra and Shah 1967). Viruses isolated from wild caught *Eretmapodites* include Rift Valley Fever virus (Smithburn, Haddow and Gillett 1948), Semliki Forest virus (Macnamara 1953), Spondweni virus (McIntosh et al. 1961, Worth et al. 1961), Nyando virus (Ardoin and Simpson 1965, Serie et al. 1968), Nkolbisson virus (Salaun et al. 1969), an unidentified viral agent MTMP131 (Henderson et al. 1969), and others.

Since mosquitoes of this genus are known and/or potential vectors of many arboviruses and are very similar to the genus *Aedes* which has many members of great medical and economic importance, it is imperative that a better knowledge of their genetics be developed. The development of a formal genetics of this genus will provide the basic tools needed for comparative genetic studies between this genus and other mosquito genera, such as the *Aedes*, in which more genetic information is available. Comparative genetic studies should lead to a greater understanding of speciation within the Culicidae. To the best of the authors' knowledge, only one formal genetic investigation of this genus has been made to date. A report of this study has been submitted to the Journal of Medical Entomology. We describe here the mutant red-eye (*re*) in *Er. quinquevittatus* and assign it to a linkage group.

MATERIALS AND METHODS

The mutant red-eye (*re*) was first isolated in 1976 by the senior author. Several red-eyed male and female pupae were isolated from the EQ-GL stock of *Er. quinquevittatus*. The resulting adults were crossed and their progeny inbred to establish a pure-breeding red-eye stock which was designated EQ-RE/GL. Another strain of *Er. quinquevittatus* (EQ-PURE) with normal eye phenotype was also used in this investigation. All of the strains used were selected from the colonies maintained at the Mosquito Genetics Labora-

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Rearing methods used were generally similar to those described by Hartberg and Gerberg (1971) for rearing *Er. quinquevittatus* and those described by Craig and VandeHey (1962) for genetic research with *Ae. aegypti*. Rearing was in an insectary room with a temperature of 27±2° C and ambient RH. Larvae were fed on a suspension of liver powder and adults were provided with dry sugar cubes and an opportunity for the females to take a blood meal from an anesthetized mouse.

Preliminary observations of mitotic chromosomes from fourth-instar larval brain cells of *Er. quinquevittatus* indicate that no heteromorphic chromosomes are present (Hartberg, unpublished). From this fact and the results obtained from the testcrosses in the present study, sex in *Er. quinquevittatus* is considered to be determined by a single gene (or a small block of chromosome) designated as *m* on linkage group I. Females are homogametic (*m/m*) and males heterogametic (*M/m*). This mode of sex determination has been demonstrated in several mosquito species (Gilchrist and Haldane 1947, McClelland 1962, Barr and Myers. 1966, Bat-Miriam and Craig 1966, Baker 1968, Hartberg and Craig 1974, Tadano 1976, Tadano and Kanda 1976). The sex locus *m* can be used as a genetic marker for linkage studies.

In the present study, the linkage relationship of red-eye (*re*) with sex (*m*) was determined from the results of testcrosses. F_1 males from reciprocal crosses between males and females from the EQ-RE/GL and EQ-PURE stocks were backcrossed to females from the EQ-RE/GL stock. This allowed for the testing of linkage between *re* and *m* in both the coupling and repulsion phase.

RESULTS AND DISCUSSION

DESCRIPTION. The normal eye color of *Er. quinquevittatus* is brownish-black. In

Table 1. Recombination between red-eye (*re*) and sex (*m*).

Trial no.	Cross: Female	Cross: Male	Female Progeny: re	Female Progeny: +	Male Progeny: re	Male Progeny: +	% recombination and S.E.[1]
1	re m / re m	+ M / re m	140	30	22	147	15.3 ± 2.0
2	re m / re m	+ M / re m	155	23	24	163	12.9 ± 1.8
3	re m / re m	+ M / re m	313	53	65	219	18.2 ± 1.5
4	re m / re m	re M / + m	34	195	166	26	14.3 ± 1.7
5	re m / re m	re M / + m	28	123	110	31	20.2 ± 2.3
6	re m / re m	re M / + m	38	155	127	33	20.1 ± 2.1
			Average % recombination				16.8 ± 0.8

[1] Standard error calculated using following formula (Serra, 1965):

$$S.E. = \sqrt{\frac{P(1-P)}{n}}$$

where P = crossover value (as fraction of 1), n = no. of individuals.

the mutant red-eye (*re*) the eye color is red and the color darkens with age. Both the ocelli and compound eye are affected, and the character can be determined in the larvae and pupae, as well as in the adults. Both males and females are affected. In the adult the red-eye appears to bulge, probably due to enlarged eye facets. Penetrance is complete. F_1 progeny from reciprocal crosses between EQ-PURE and EQ-RE/GL were normal, indicating that *re* is recessive.

LINKAGE. Table 1 gives the data obtained from testcrosses between F_1 males and EQ-RE/GL (red-eye) females. The genotypes of the individuals in each cross are given in the table. The data indicate that *re* is sex-linked, with an average recombination value of 16.8± 0.8 (range 12.9± 1.8 to 20.2± 2.3).

It is interesting to compare *re* in *Er. quinquevittatus* to similar sex-linked recessive eye color mutants reported from species in the closely related genus *Aedes* (McClelland 1962, Hartberg and Craig 1974, Tadano 1976). With the discovery of other mutants in *Er. quinquevittatus*, and establishment of linkage maps, it will become possible to make comparisons to other species where more genetic information is available. Such comparisons should prove instructive in determining evolutionary relationships.

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ANOPHELES NUNEZTOVARI AND MALARIA TRANSMISSION IN SURINAM

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ABSTRACT. During recent entomological surveys a tremendous increase in numbers of *Anopheles nuneztovari* Gabaldon has been observed in the interior of Surinam. The construction of the Afobaka dam, which gave rise to the Brokopondo storage lake, was the main factor responsible for this increase. The scarcity of *An. darlingi*, the principal vector of *Plasmodium falciparum* in Surinam, and the failure to capture this species during recent epidemics of malignant malaria in certain areas where *An. nuneztovari* abound, indicate that the latter might be involved in active transmission of the parasite. Breeding experiments with *An. nuneztovari* showed a duration of 1 day for the egg stage, 7 days for the larval stages and 1 day for the pupal stage. The gonotrophic cycles may last 4 days each, except the 1st which takes 5 days. The daily biting activity pattern of this species shows a unimodal pattern with a sharp peak at 6:00–7:00 pm. The maximum and minimum parous rates which may be reached over a longer period of time are 0.69 and 0.14 respectively, the mean being 0.34. This rather high parous rate indicates that this species may well act as a good vector of pathogens, because it feeds readily on man and occurs in large numbers during certain periods of the year. It appears that the population of *An. nuneztovari* at Brownsweg is fully susceptible to DDT, dieldrin and malathion.

INTRODUCTION

Anopheles nuneztovari Gabaldon was initially reported from Surinam in 1949 (Van der Kuyp 1949). Until now this species was considered to be relatively unimportant because of its limited geographical distribution and abundance. Its role as a potential vector of *Plasmodium falciparum* was totally neglected. This paper presents the results of recent entomological surveys which show that this species now occupies vast areas in the interior of Surinam, where it occurs in great numbers. It appears that in a large part of the interior *An. nuneztovari* is at present the dominant anthropophilic mosquito, outnumbering other species by far, and there are indications that it might have been involved in recent malaria outbreaks. It became clear