Cut antenna, a new sex-limited mutant of *Aedes togoi*

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Abstract: A new recessive, sex-limited mutant, cut antenna (*ca*), of the mosquito *Aedes (Finlaya) togoi* (Theobald) was located in the order of *p* (pigmented pupa)—*ru* (ruby eye)—*ca* in linkage group 2. The recombination values between *p* and *ru*, and between *ru* and *ca* were 27.06 ± 1.70 to $31.31 \pm 1.96\%$ and 6.98 ± 1.08 to $11.77 \pm 1.24\%$, respectively. 4 to 7 antennal segments are lost in *ca* females but the *ca* allele does not affect male antennae; the allele appears to exhibit complete penetrance with some variation in its expressivity.

Basic genetics of the mosquito *Aedes (Finlaya) togoi* (Theobald), a natural or experimental vector of filariae, has been studied in our laboratory to accumulate the materials needed for comparative genetic studies among the *Aedes* mosquitoes and for genetic analysis of problems of medical importance. Eight genetic markers have been placed in all three linkage groups of this mosquito, its haploid chromosome number being three (Tadano, 1977a, 1978), but further work of this series should be continued for establishment of precise linkage groups in this species.

The inheritance of a new recessive mutant, cut antenna, was investigated using representative markers of the three linkage groups. This paper presents results of the crosses involving cut antenna.

MATERIALS AND METHODS

Several female pupae of cut antenna (*ca*) were detected during microscopic work on single families of the Miura strain in July, 1975. No males of this trait have been found in all generations of this colony; therefore, each generation was maintained

by putting *ca* females together with their wild-type brothers into the cage. For this reason only *ca* females were utilized for all crosses performed in the present study.

The Miura and Manazuru strains were employed as wild-type strains for production of heterozygotes for the mutant alleles used here. The Miura and Manazuru strains were collected in rock pools on the seashores at Miura City and Manazuru, Kanagawa Prefecture, respectively.

The methods for rearing and crossing mosquitoes were same as those previously reported (Tadano, 1976, 1977b). Mass crosses were made in all experiments, but single blooded females were isolated in separate plastic cups and each egg batch laid by single females was hatched in a plastic box containing salted tap water (about 2%); the hatched larvae were reared separately as a family.

After classification of offspring phenotypes was performed in each family, χ^2 -tests were made to examine whether observed phenotype ratios in each family fit the expected ratios. Only families in which all the observed ratios did not differ significantly ($P > 0.05$, with one degree of freedom) from the expected were pooled for subsequent statistical treatment, from which all other

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Fig. 1 The cut antenna and wild-type antenna in pupal and adult stages (A, C: wild type, B, D: cut antenna)
Arrows indicate tips of antennae.

families were discarded.

RESULTS AND DISCUSSION

A normal antenna is composed of 13 segments, while 4 to 7 segments of these are lost in *ca* females and so the antennae are about a half as long as normal. The *ca* trait can be distinguished in pupae from the wild type; as seen in a *ca* pupa (Fig. 1), remaining segments of the antenna become slightly thickened and sometimes bent. The *ca* allele appears to exhibit complete penetrance, although some variation in its expression was noted and a few *ca* individuals are likely to experience difficulty in emergence.

Six crosses, of which three were $F_1 \times F_1$ crosses and the other three were testcrosses, were made to find out which linkage group the *ca* belongs to. Scores from all the crosses are given in Table 1; here the alleles

above lines in heterozygous parental genotypes are of maternal origin and the alleles below the lines were derived from males. The *s* (straw-colored larva) is a linkage group 1 marker; the *ru* (ruby eye) and *p* (pigmented pupa) alleles are in linkage group 2, while the *y* (yellow larva) belongs to the group 3 (Tadano, 1977b, c).

Testcrosses (D, E, and F) produced no single *ca* male, which indicates sex-limited inheritance of the *ca* allele. From data in each cross (A through F), linkage relationships among the alleles involved were tested by χ^2 , following the formula described by Bailey (1961). The χ^2 values among *ca*, *ru*, *p*, *s*, and *y* are shown in Table 2; the values between *ca* and *ru*, between *ca* and *p*, and between *ru* and *p* are significant at 1% level, although the two values (4.46 and 2.10) for *ca-ru* (cross C) and *ca-p* (cross B) are exceptionally low. This fact strongly suggests existence of linkage among the al-

Table 1 Results of F₁×F₁ crosses (A, B, and C) and testcrosses (D, E, and F)

Cross	Genotype Female×Male	Progeny						Phenotype					
		Female			phenotype			Male			phenotype		
		+	+	+	y	y	y	+	+	+	y	y	y
A	$\frac{ca}{+} \frac{+}{ru} ; \frac{+}{y} \times \frac{ca}{+} \frac{+}{ru} ; \frac{+}{y}$	+	+	+	+	+	+	+	+	+	+	+	+
		+	+	+	ru	ru	ru	+	+	+	ru	ru	ru
		+	+	+	ca	ca	ca	+	+	+	ca	ca	ca
		230	46	96	1	77	48	2	269	0	81	0	25
B	$\frac{ca}{+} \frac{+}{ru} \frac{+}{p} \times \frac{ca}{+} \frac{+}{ru} \frac{+}{p}$	+	+	+	+	p	p	p	+	+	p	p	p
		+	+	+	ru	ru	ru	ru	+	+	ru	ru	ru
		+	+	+	ca	ca	ca	ca	+	+	ca	ca	ca
		153	37	37	0	28	7	44	183	0	37	0	25
C	$\frac{+}{s} ; \frac{ca}{+} \frac{+}{ru} \times \frac{+}{s} ; \frac{ca}{+} \frac{+}{ru}$	+	+	+	+	s	s	s	+	+	s	s	s
		+	+	+	ru	ru	ru	ru	+	+	ru	ru	ru
		+	+	+	ca	ca	ca	ca	+	+	ca	ca	ca
		71	15	25	0	18	5	10	94	0	21	0	14
D	$\frac{ca}{ca} \frac{ru}{ru} \frac{p}{p} \times \frac{ca}{+} \frac{+}{ru} \frac{+}{p}$	+	+	+	+	p	p	p	+	+	p	p	p
		+	+	+	ru	ru	ru	ru	+	+	ru	ru	ru
		+	+	+	ca	ca	ca	ca	+	+	ca	ca	ca
		1	90	172	15	8	189	69	90	0	205	0	83
E	$\frac{ca}{ca} \frac{ru}{ru} \frac{p}{p} \times \frac{ca}{+} \frac{+}{ru} \frac{+}{p}$	12	104	49	4	2	52	109	152	0	46	0	135
		219	22	16	76	86	6	36	221	0	71	0	245
F	$\frac{ca}{ca} \frac{ru}{ru} \frac{p}{p} \times \frac{ca}{+} \frac{+}{ru} \frac{+}{p}$	+	+	+	+	p	p	p	+	+	p	p	p
		+	+	+	ru	ru	ru	ru	+	+	ru	ru	ru
		+	+	+	ca	ca	ca	ca	+	+	ca	ca	ca
		7											

F* indicates number of families pooled.

Table 2 Chi² linkage tests for F₁×F₁ crosses and testcrosses with one degree of freedom

Cross	<i>ca-ru</i>	<i>ca-p</i>	<i>ru-p</i>	<i>ca-s</i>	<i>ca-y</i>	<i>ru-y</i>	<i>ru-s</i>
A (F ₁ ×F ₁)	21.19*				1.06	3.19	
B (F ₁ ×F ₁)	13.67*	2.10	61.38*				
C (F ₁ ×F ₁)	4.46**			0.11			0.44
D (testcross)	413.88*	68.02*	78.14*				
E (testcross)	229.84*	24.46*	50.36*				
F (testcross)	397.65*	84.71*	143.15*				

* Significant ($P \leq 0.01$)** $0.05 > P > 0.02$

Table 3 Percent recombinations and (±) standard errors obtained from testcrosses

Cross	<i>ca-ru</i>	<i>ru-p</i>	<i>ca-p</i>
D	6.98±1.08	31.31±1.96	32.56±1.98
E	9.25±1.55	30.93±2.48	36.71±2.59
F	11.77±1.24	27.06±1.70	32.35±1.79

les, *ca*, *ru*, and *p*. and that the other alleles, *s* and *y*, are inherited independently of each other, as previously reported (Tadano, 1977b, c).

Therefore, percent recombinations among the three alleles, *ca*, *ru*, and *p* were estimated and are given in Table 3, in which only the recombination values resulted from testcrosses are tabulated since linkage data from testcrosses are more reliable than those from F₁×F₁ crosses. All three sets of recombination values calculated from results of crosses, D, E, and F give good evidence that the alleles are located in the order of *ca-ru-p*; the recombination value for the *ca-ru* segment varied from 6.98±1.08 to 11.77±1.24%, and the recombination distance between *ru* and *p* was very much greater ranging between 27.06±1.70 and 31.31±1.96%, which agree closely with the values obtained in previous studies.

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REFERENCES

- Bailey, N. T. J. (1961): Introduction to the mathematical theory of genetic linkage, 294 pp., Oxford Press, London.
- Tadano, T. (1976): A new sex-linked mutant, reddish eye, of the mosquito *Aedes togoi*. *Jap. J. Sanit. Zool.*, **27**: 247-249.
- Tadano, T. (1977a): Inheritance of a new mutant, plum eye, in the mosquito *Aedes togoi*. *Mosq. News*, **37**: 440-443.
- Tadano, T. (1977b): Genetics of three new mutants, straw-colored larva, ruby eye and pigmented pupa, in *Aedes (Finlaya) togoi* (Diptera: Culicidae). *J. Med. Entomol.*, **14**: 33-37.
- Tadano, T. (1977c): The inheritance of a mutant yellow larva in the mosquito *Aedes togoi*. *Ann. Trop. Med. Parasitol.*, **71**: 361-365.
- Tadano, T. (1978): Genetics of a new mutant, curved wing, of the mosquito *Aedes togoi*. *Ann. Trop. Med. Parasitol.*, in press.

摘 要

トウゴウヤブカの限性突然
変異体 cut antenna

この蚊の遺伝子連鎖群の研究の一部として, cut antenna (*ca*) の遺伝様式を調べた. この変異は雌の触角にのみ現われるもので, 雄の触角には現われない. すなわち, 野生型の雌の触角は13節からできているが, この変異体では4ないし7節欠失している. この遺伝子は第2連鎖群に属し, *ca*—(7~12%)—*ru* (ruby eye)—(27~31%)—*p* (pigmented pupa) の順序に並んでいる. 表現度に少々の変異はあるが, 浸透度は完全であると思われる.