

## MUTANT FORMS OF ANOPHELES ALBIMANUS WIEDEMANN

(DIPTERA: CULICIDAE)

LLOYD E. ROZEBOOM,<sup>1</sup> *Laboratories of Medical Entomology, Department of Pathobiology, School of Hygiene and Public Health, the Johns Hopkins University, Baltimore, Md.*

*Anopheles albimanus* is one of the mosquitoes which presents problems to malaria eradication in that it has developed insecticide resistance and also appears to adjust behavioristically to household residual sprays. In our studies on dieldrin resistance, we have been rearing individual progenies, inbreeding them, and again obtaining individual progenies resulting from brother-sister matings. Although this was being done primarily for other purposes, this did offer an opportunity to look for mutant forms. It is the purpose of this paper to report the findings of three mutants of *A. albimanus* recognizable by morphological characters.

*The bisignatus mutant.* The appearance of the hind tarsal segments of normal ("wild") *albimanus* is shown in Figure 1. The second hind tarsal is about one half black basally; the distal part of this segment, and all of the third and fourth segments are white, and the fifth segment has a basal black ring. The *bisignatus* leg is shown in Figure 2. The third hind tarsal segment has a basal black ring, so that the broad white area of the hind tarsi is interrupted by two black rings. This figure also shows the second segment to be almost entirely black, but in most specimens the second segment will show a more moderate increase in darkening, so that the distal fourth to half is white.

From a population of *A. albimanus* from El Salvador, some 60 individual progenies were reared, representing F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub>, and F<sub>4</sub> generations. All were given at least a cursory examination while the specimens were being transferred to various containers in tests for insecticide resistance, and several groups were examined carefully under the microscope. The *bisignatus* mutant was found twice; and by inbreeding and selection, a colony was established. The pedigree of the *bisignatus* colony is as follows:

Parent ♀ 8 from breeding cage "wild" type

↓  
F<sub>1</sub> ♀ A —wild type

↓  
F<sub>2</sub> ♀ e —wild type, but several siblings with this black ring at base of second tarsal segment

↓  
F<sub>3</sub> ♀ ♀ 2 and 3—with ring on second tarsal segment

SOUTH EAST ASIA MOSQUITO PROJECT  
DEPARTMENT OF ENTOMOLOGY  
SMITHSONIAN INSTITUTION  
UNITED STATES NATIONAL MUSEUM  
WASHINGTON, D. C. 20560

<sup>1</sup>These observations were made in the course of a program supported in part by research grants from the National Institutes of Health and the Pan American Health Organization.

## TEN KILOMETERS OF SWARMS OF AN ANT

Suitable meteorological and biological conditions regularly cause the emergence of great numbers of winged ants at one time, but the following case is notable for the numbers of individual swarms involved. The visibility of the swarms was also exceptional, since they occurred in a mountain valley without trees or habitations to impede the view and were clearly silhouetted against a continuous mountain ridge. The location was Western Argentina, approximately in Longitude 71° West, Latitude 39° South, 30 Oct. 1960.

The ants were *Araucomyrmex tener* (Mayr), described in 1868 (Ann. Soc. Natural. Modena, 3: 166) as *Dorymyrmex tener* from Mendoza, Argentina. The worker is a medium-sized ant and the females are markedly larger than the males. The species is confined to Southern South America. Time was limited in which to make observations since my party was travelling by truck, jolting along a rocky trail, and it was necessary to make camp before dark.

Swarms of ants had been noted in the late afternoon along the rough trail, but it was not until 6:00 P.M. that their abundance became notable. By this time the later afternoon sun caused them to be clearly visible against the shaded east slope of a largely north-south ridge.

Each swarm appeared to be an independent unit and the ants, zigzagging in their flight, formed columns of an estimated one-half meter in diameter and from less than one to perhaps two meters in height. Often the swarms nearly touched; commonly they were one to several meters apart. The columns probably contained individuals of the order of magnitude of 500 to several thousand. The columns at times suggested the wavering light of candles, as they swayed in the breeze. The columns most visible were several meters above the ground.

By the time the site of the night's camp was reached at 7:00 P.M., the swarming had stopped. Fully 10 kilometers of trail had been traversed and over much of this distance numerous swarms had been continuously in view. Many had been intercepted by the truck windshield. The site of the camp offered one of the few places where the ground sloped comparatively little, and here as elsewhere were numerous craters of this ant. The soil surface was dry and the worker ants, with some males, were milling about. Many males were scattered through the grass. A few females were at the entrances. The nests were of multiple-crater type like those of the Holarctic *Lasius* or *Acanthomyops*. A low sound caused me to place my ear within a few centimeters of the ground and a distinct buzzing or stridulation was markedly apparent. Each ant by itself made an almost imperceptible sound and thousands must have been stridulating to produce the volume of sound that was heard. There was also a faint odor, and when one or two workers were crushed between the fingers the odor was distinctive. It was not the common *Tapinoma*-type of related ants and could not be likened to any well-known odor.

NEAL A. WEBER, *Swarthmore College, Swarthmore, Penna.*



F<sub>4</sub> adults from ♀♀ 2 and 3 were used to start the *bisignatus* colony. These included 10 mutant ♀♀, and 25 mutant ♂♂. To ensure egg production, 6 normal ♀♀ were also placed in the breeding cage.

The *bisignatus* mutant was also noted in another series of brother-sister matings; of the progeny produced by one F<sub>2</sub> ♀, 1 of 19 ♀♀ and 3 of 14 ♂♂ were *bisignatus*.

*The trisignatus mutant.* This is characterized by a black ring at the base of the third and fourth, as well as the fifth hind tarsal segment (Figure 3). Individuals with these markings were fairly common among the progenies of the F<sub>4</sub> ♀♀ in the first series. The following table shows the distribution of the three kinds of individuals among the progenies of four *bisignatus* and 1 "wild" type F<sub>4</sub> females.

No.	Parent ♀ Type	Sex	Progeny—F <sub>5</sub>		
			Normal	<i>bisignatus</i>	<i>trisignatus</i>
1	bisig	♀	0	61	8
		♂	0	60	8
2	"wild"	♀	10	55	0
		♂	2	50	1
5	bisig	♀	4	63	0
		♂	0	50	0
6	bisig	♀	12	30	0
		♂	3	38	0
8	bisig	♀	1	22	1
		♂	0	24	7

In subsequent generations, as continued selection is being made for the *bisignatus* colony, the *trisignatus* form continues to appear. Apparently it represents a more marked expression of the *bisignatus* gene or genes.

*Short-palp mutant.* Among the progeny of ♀ 5 in the above table, was one *bisignatus* female which also had one short palp (Figure 4). We were unable to bring about the insemination of this specimen. This mutant has not been found a second time.

DISCUSSION

Studies of the genetic basis of insecticide resistance in mosquitoes, as well as other work on the genetics of mosquitoes, have stimulated a search for mutant marker genes. Laven (1956) and Kitzmiller (1958) showed it was possible to produce several mutants of *Culex pipiens* by exposure to X-rays. Craig and Vandehey (1962) and Vanhehey and Craig (1962) described a number of mutants of *Aedes*

*aegypti* obtained by inbreeding. It is evident that we are only beginning to appreciate the potential existence of many mutant forms of mosquito species. If these can be established as colonies, they should be of great value in advancing our knowledge of mosquito genetics.

The white hind-footed *Nyssorhynchus* group of anophelines show considerable variation in colorational markings. *A. triannulatus* was the name given by Neiva and Pinto (1929b) to a 3-ringed form of a mosquito later described by Petrocchi (1925) as *A. bachmanni* with the normal tarsal markings. A 2-ringed form of *triannulatus* (*cuyabensis*) also may be found. Anduze (1948) has described 2- and 3-ringed forms of *A. aquasalis*, under the names *guarauno* and *delta*.

Hoffmann (1938) proposed that the 2- and 3-ringed forms of *A. albimanus* should be recognized as varieties, with the names *bisignatus* and *trisignatus*. Vargas (1940) expressed the belief that these are only variations of *A. albimanus*, and that they have no hereditary basis. Vargas and Palacios (1950) referred to the extra rings as being an unstable character which they interpreted as a manifestation of melanism.

The present study demonstrates that the *bisignatus* and *trisignatus* mutants have a genetic basis. The mechanism of inheritance has not as yet been determined, but the fact that the genes for the character exist in normal appearing adults suggests they are recessive. Whether further selection of the *trisignatus* form will lead to the establishment of a population homozygous for this character is uncertain. One attempt at such selection has failed.

The fact that aberrant kinds of *Nyssorhynchus* mosquitoes have been observed from time to time in nature suggests that these species may have considerable potential value for genetic studies. If the gene for extra tarsal rings is linked with other characters of selective value in a given area, a population consisting to a large extent of rather strikingly different individuals may be found. An example may be *A. rondoni*, which is separable from *A. evansae* (= *strodei*) with certainty only by its 2-ringed hind tarsus. *A. rondoni* was described by Neiva and Pinto (1922a) from 3 specimens taken in a region of Matto Grosso where "*Cellia trasimaculata*" (? = *evansae*) was also present. Apparently the 2-ringed form, represented by 3 specimens in a general collection of anophelines, may have been fairly abundant here. In our own departmental collection, there is a series of 17 adult specimens collected in March, 1927, at Ledesma, Argentina, by N. C. Davis. From the observations made by Davis and Shannon (1928), it is evident that *rondoni* was relatively abundant at the time in the vicinity of Ledesma. Because progeny reared from captured females bred true, Davis (1933) argued that *rondoni* could not be "a mere variety of *A. tarsimaculatus* or of *A. strodei*." But since the *bisignatus* mutant of *albimanus* will breed true after selection and inbreeding, it seems reasonable that selection in the field may have produced the population of *rondoni* at Ledesma. It seems quite possible that *A. evansae* Bréthes (1926) must be synonymized with *A. rondoni* Neiva and Pinto (1922).

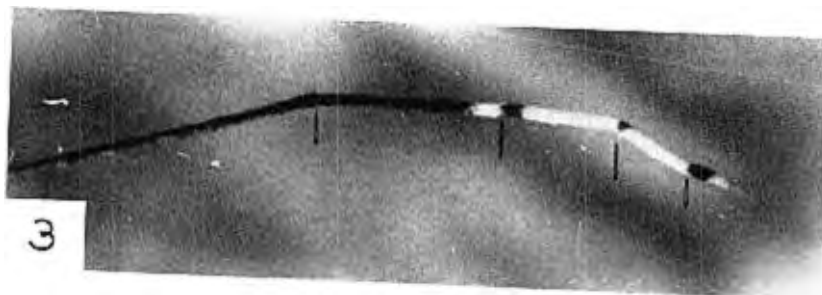
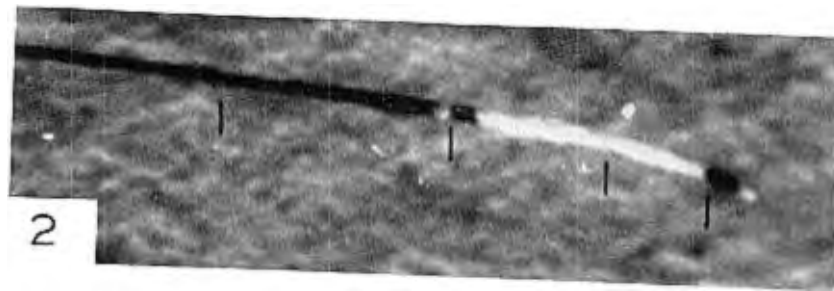
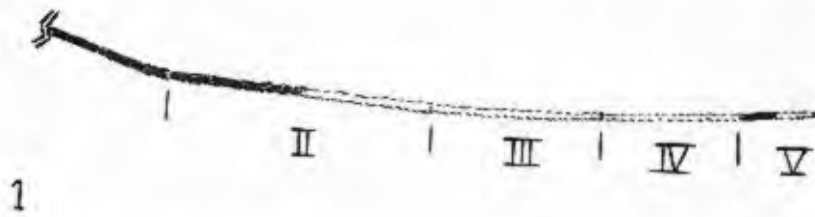


Fig. 1, Hind tarsal segments II to V of normal, i.e. "wild type" *A. albimanus*; Fig. 2, Hind tarsus of *bisignatus*, showing a black ring at the base of the third segment; Fig. 3, Hind tarsus of *trisignatus*, showing a black ring at the base of the third and fourth segments; Fig. 4, Mutant female with a short right palpus.

The mutants with the extra tarsal rings are quite spectacular, but it seems likely that potentially there are many others. Mutants with biological advantages may also exist among the *Nyssorhynchus* species, and aside from the development of insecticide resistance, selection for these mutants may complicate malaria eradication programs.

#### SUMMARY AND CONCLUSIONS

Three mutant forms of *Anopheles albimanus* Wiedemann are described. Through selection and inbreeding, a colony of the *bisignatus* mutant has been established. Extra tarsal rings have been observed in wild-caught specimens of several *Nyssorhynchus* species, and it appears that these, too, are mutant forms. The existence in some areas of fairly large populations of *A. rondoni* suggests that selection for these mutants may take place in nature, perhaps because of linkage with other characters conferring a biological advantage in the particular area or season.

#### REFERENCES

- Anduze, P. J.**, 1948. Dos variedades nuevas de *A. aquasalis*. Bol. Med. (Creole Pet. Corp., Caracas) 1: 17-19.
- Craig, G. B., Jr.**, and **R. C. Vandehey**, 1962. Genetic variability in *Aedes aegypti* (Diptera: Culicidae). I. Mutations affecting color pattern. Ann. Ent. Soc. Amer. 55: 47-58.
- Davis, N. C.**, 1933. Notes on some South American mosquitoes. Ann. Ent. Soc. Amer. 26: 277-284.
- Davis, N. C.**, and **R. C. Shannon**, 1928. The habits of *Anopheles rondoni* in the Argentine Republic. Amer. Jour. Hyg. 8: 448-456.
- Hoffman, C. C.**, 1938. La formacion de razas en los *Anopheles* mexicanos. II. *Anopheles albimanus* y sus variedades en la Republica Mexicana. Ann. Inst. Biol. 9: 167-180.
- Kitzmiller, J. B.**, 1958. X-ray induced mutation in the mosquito *Culex fatigans*. Exp. Parasit. 7: 439-462.
- Laven, H.**, 1956. X-ray induced mutations in mosquitoes. Proc. Roy. Ent. Soc. Lond. (A) 31: 17-19.
- Neiva, A.**, and **C. Pinto**, 1922a. O contribuicao para o conhecimento das anophelinas do Estado de Matto Grosso com a descricao de uma nova especie. Brasil-Med. 2: 321-322.
- Neiva, A.**, and **C. Pinto**, 1922b. Consideracoes sobre o genero "Cellia" Theobald com a descricao de uma nova especie. Brasil-Med. 2: 355-357.
- Petrocchi, J.**, 1925. Descripcion de un nuevo *Anopheles*. Rev. Inst. Bact. Dep. Nac. Hig. 4: 69-75.
- Root, F. M.**, 1926. Studies on Brazilian mosquitoes I. The anophelines of the *Nyssorhynchus* group. Amer. Jour. Hyg. 6: 684-717.
- Vandehey, R. C.**, and **G. B. Craig, Jr.**, 1962. Genetic variability in *Aedes aegypti* (Diptera: Culicidae). II. Mutations causing structural modifications. Ann. Ent. Soc. Amer. 55: 58-69.
- Vargas, L.**, 1940. Clave para identificar las hembras de *Anopheles* Mexicanos. Rev. Inst. Salub. Enf. Trop. 1: 199-203.
- Vargas, L.**, and **A. Martinez Palacios**, 1950. Estudio taxonomico de los mosquitos anophelinos de Mexico. Sec. Salub. Asist. Mexico viii + 143 pp.