

COMPARATIVE INFECTIVITY OF TWO STRAINS OF *PLASMODIUM FALCIPARUM* TO *ANOPHELES QUADRIMACULATUS* SAY, *ANOPHELES FREEBORNI* AITKEN, AND *ANOPHELES ALBIMANUS* (WIED.)

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Studies on the comparative infectivity of *Plasmodium falciparum* to *Anopheles quadrimaculatus* and *A. albimanus* have been reviewed previously (Collins, 1962). Studies on the comparative infectivity of *P. falciparum* to *A. quadrimaculatus* and *A. freeborni* have been reported only once. In this instance, Burgess and Young (1946) reported one comparative feeding on the McLendon strain of *P. falciparum* in which the *A. freeborni* had 1.18 times the number of oocysts per gut as did the *A. quadrimaculatus*.

Reported here are the results of comparative studies using two strains of *P. falciparum* from widely separated geographical origins and *A. quadrimaculatus*, *A. albimanus*, and *A. freeborni*.

METHODS AND PROCEDURES. The Thailand strain of *P. falciparum* is a multi-resistant strain which has been described by Young, *et al.*, (1962). It was originally isolated from a person who had served in a U. S. Naval Unit in Thailand. The McLendon strain was isolated from a resident of South Carolina in 1940 by Young, McLendon and Smarr (1943).

The *A. quadrimaculatus* (Q-1 strain) was originally from the Southeastern United States and has been maintained in the laboratory since 1941. The *A. albimanus* (A-9 strain) was originally from El Salvador and was obtained through the courtesy of Dr. H. G. Simkover, Shell Development Company, Modesto, Cali-

fornia. The colony has been maintained since 1960. The *A. freeborni* (F-1 strain) was from Marysville, California, and has been maintained in the laboratory since 1944.

The patients were adult males being treated for neurosyphilis. Two patients were infected with the Thailand strain by intravenous inoculation of fresh parasitized blood from a donor patient. Patient A first showed parasites four days after inoculation. Gametocytes were found 8 days later. Patient B first showed parasites 10 days after inoculation and gametocytes 9 days later. All comparative feedings were during the first wave of sexual parasites.

For the McLendon strain, the patient used in the Q-1 and A-9 comparisons was infected by intravenous inoculation of parasitized blood which had been preserved frozen in a dry ice chest (-78°C .) for slightly over 5 years (1,921 days). The asexual parasites were first found 9 days after inoculation. Gametocytes appeared 7 days later. The comparative feedings (Q-1/A-9) were during the first gametocyte wave.

The 15 Q-1/F-1 comparative feedings on the McLendon strain were done at various times on 11 different patients. They were made on the first to the fifth gametocyte wave.

No antimalarials were given patients during the study period.

Three- to five-day-old adult female mosquitoes were caged in lots of 100 to 150 in pint ice cream carton cages and allowed to feed through the screened top on a patient's leg. Engorged mosquitoes were incubated in these cages at 78°F . to 80°F . and fed 5 percent honey water daily in a

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cellulose sponge. Eight to 10 days after the feeding, the mosquitoes were dissected and the guts microscopically examined for the presence of oocysts.

RESULTS. The results of the comparative infection studies using the Thailand strain of *P. falciparum* are shown in Table 1. The *A. freeborni* (F-1) had a higher percentage of infection than the

quitoes had 2.34 times the gut infection index as the standard Q-1 mosquitoes. The gut infection index of the Q-1 mosquitoes was 1.13 times that found in the A-9 mosquitoes. By combining the results of the comparative feedings on the McLendon strain, the F-1 mosquitoes were estimated to have a gut infection index 2.64 times that of the A-9 mosquitoes.

TABLE 1.—Comparative infectivity of *P. falciparum* (Thailand strain) to 3 species of *Anopheles*.

Mosquitoes	Comparative feedings	Mosquitoes dissected	Percent infection	Gut infection index	Gut infection index ratio
<i>A. quadrimaculatus</i> Q-1	10	248	68.5	668	(F-1/Q-1) 12.4
<i>A. freeborni</i> F-1		133	87.2	8266	
<i>A. quadrimaculatus</i> Q-1	15	323	55.1	746	(Q-1/A-9) 622
<i>A. albimanus</i> A-9		329	0.3	1.2	
<i>A. freeborni</i> F-1	8	99	86	8183	(F-1/A-9) 3558
<i>A. albimanus</i> A-9		175	0.6	2.3	

A. quadrimaculatus (Q-1) mosquitoes, which in turn had a higher percentage of infection than the *A. albimanus* (A-9) mosquitoes. The gut infection index (average number of oocysts per 100 guts) followed the same pattern. The F-1 mosquitoes had 12.4 times as many oocysts per gut as did the Q-1 mosquitoes. The A-9 mosquitoes were so lightly infected that only one individual out of a total of 339 dissected was positive and it had only four oocysts.

The results of the comparative feedings on the McLendon strain of *P. falciparum* are shown in Table 2. The percentage of infection was again greater in the F-1 than in the Q-1 mosquitoes which in turn was greater than that found in the A-9 mosquitoes. The gut infection index followed a similar pattern. However, the differences were not as great as those found with the Thailand strain. The F-1 mos-

DISCUSSION. Eyles and Young (1950) demonstrated that *A. quadrimaculatus* when fed simultaneously with a Panama strain of *A. albimanus*, proved more susceptible to a coindigenous United States strain of *P. falciparum*. Jeffery, *et al.* (1950) showed that the reciprocal relationship also existed, in that a Panama strain of *A. albimanus* when fed simultaneously with a United States strain of *A. quadrimaculatus* proved more susceptible to a coindigenous Panama strain of *P. falciparum*.

A summary of the findings with the two strains of *P. falciparum* presented here and the Colombia strain presented previously (Collins, 1962) is shown in Table 3. The *A. quadrimaculatus* which is our standard has been given the designation of 100. None of the strains of *P. falciparum* studied can be considered as coin-

TABLE 2.—Comparative infectivity of *P. falciparum* (McLendon strain) to 3 species of *Anopheles*.

Mosquitoes	Comparative feedings	Mosquitoes dissected	Percent infection	Gut infection index	Gut infection index ratio
<i>A. quadrimaculatus</i> Q-1	15	338	48.2	651	(F-1/Q-1) 2.34
<i>A. freeborni</i> F-1		322	62.4	1521	
<i>A. quadrimaculatus</i> Q-1	8	200	38.0	127	(Q-1/A-9) 1.13
<i>A. albimanus</i> A-9		153	26.8	112	

TABLE 3.—Theoretical relative evaluation of infectivity of 3 strains of *P. falciparum* to 3 species of *Anopheles* using *A. quadrimaculatus* as a standard (=100).

Malaria strain	<i>A. quadrimaculatus</i> (Q-1 strain)	<i>A. freeborni</i> (F-1 strain)	<i>A. albimanus</i> (A-9 strain)
McLendon	100	234	88
Thailand	100	1237	1
Colombia	100	..	32

igenous with the A-9 strain of *A. albimanus*. However, the marked differences in infectivity indicate a much closer relationship of the McLendon and Colombia strains of *P. falciparum* to the A-9 strain of *A. albimanus* than is found between the Thailand strain of *P. falciparum* and this mosquito.

With the two strains tested using the F-1 mosquitoes, it was found that this mosquito is more heavily infected than the other species. The F-1 strain of *A. freeborni* appears to be similar to the Q-1 strain of *A. quadrimaculatus* in that it is susceptible to infection by *P. falciparum* from widely separated geographical origins.

ACKNOWLEDGMENTS. The authors wish to acknowledge the technical assistance of Mr. Jimmie C. Skinner, Mr. Thomas S. Kearse, and Mrs. Jane H. Henson, Biological Laboratory Technicians.

SUMMARY. Comparative studies on the infectivity of strains of *Plasmodium falciparum* from South Carolina, U. S. A., and from Thailand, to *Anopheles freeborni*,

A. quadrimaculatus, and *A. albimanus* indicated that the first was the more heavily infected. The *A. albimanus* varied greatly in susceptibility and was least infective to the *P. falciparum* from Thailand.

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