

THE TRANSFER OF *PLASMODIUM FALCIPARUM* FROM MAN TO THE MARMOSET, *SAGUINUS GEOFFROYI**

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ABSTRACT: Thirty-two *Saguinus geoffroyi*, 25 *Aotus trivirgatus*, 5 *Ateles fusciceps*, 2 *Alouatta villosa*, and 1 *Cebus capucinus* were inoculated with bloods infected with *Plasmodium falciparum*. Four *S. geoffroyi* became infected. The parasite inoculum for the infected primates ranged from 5 to 671×10^6 , the prepatent period from 1 to 2 days, the patent period from 4 to 15 days, the maximum parasitemia from 40 to 22,660 per mm^3 , and the day of patency of maximum parasitemia from 2 to 6. One attempt to transfer the infection from an infected *S. geoffroyi* to another was unsuccessful. Gametocytes appeared in one infected *S. geoffroyi* but attempts to infect *Anopheles albimanus* mosquitoes failed.

The appearance of drug-resistant strains of *Plasmodium falciparum* has stimulated the search for primates that could be used as experimental hosts for this malaria parasite. Successful infections have been reported in the howler monkey, *Alouatta villosa*, by Taliaferro and Cannon (1934) and Taliaferro and Taliaferro (1934); the chimpanzee, *Pan satyrus*, by Bray (1958); the whitehanded gibbon, *Hyllobates lar*, by Ward et al. (1965) and Gould and Cadigan (1966); and the macaque monkeys, *Macaca mulatta siamica*, *M. nemestrina*, and *M. iris*, by Cadigan et al. (1966). The lack of any follow-up on the work with howler monkeys and of any work with other New World primates has prompted our present activity to ascertain the susceptibility of Panamanian primates to *P. falciparum*.

MATERIALS AND METHODS

Methods for handling primates, bloods, and mosquitoes have been detailed elsewhere (Porter and Young, 1966). Fresh falciparum bloods were obtained from persons naturally infected in the Republic of Panama. Falciparum bloods obtained from experimentally infected prison volunteers in the United States were sent to us frozen. Thirty-two marmosets, *Saguinus geoffroyi*; 25 night monkeys, *Aotus trivirgatus*; 5 black spider monkeys, *Ateles fusciceps*; 2 black howler monkeys, *Alouatta villosa*; and 1 whiteface monkey, *Cebus capucinus*, were inoculated. Eighteen of the marmosets and 16 of the night monkeys were inoculated with

blood which had been frozen. All other primates were inoculated with fresh blood. Blood was injected either intravenously or intraperitoneally. The parasite inoculum ranged from < 0.1 to 671×10^6 .

RESULTS

The negative animals were followed routinely for 30 days or until they died, if earlier. Only four primates, all marmosets, became infected (Table 1). All four had been inoculated intraperitoneally with fresh falciparum blood. Table II shows that one of the infected marmosets had been splenectomized and the other three had been administered azathioprine (Imuran®). The drug was administered orally by stomach tube at the rate of 5 mg/kg of body weight at the time of inoculation of parasitized blood. Subsequently the drug was administered from 1 to 4 days at the rate of 2.5 to 5 mg/kg of body weight. One marmoset, number 701, was infected from one blood source and the other three from a second source. The parasite inoculum in the infected marmosets ranged from 5 to 671×10^6 , the prepatent period from 1 to 2 days, the patent period from 4 to 15 days, the maximum parasitemia from 40 to 22,660 per mm^3 , and the day of patency of maximum parasitemia from 2 to 6.

In an attempt to cause a second period of parasitemia after the initial parasitemia had disappeared, the three intact marmosets were splenectomized and the previously splenectomized marmoset was inoculated with uninfected human red blood cells which had been separated by centrifugation, washed three times, and resuspended in physiological saline. Patent parasitemia did not recur in any of the four marmosets.

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TABLE I. Attempts to transfer *Plasmodium falciparum* to Panamanian primates.

| Man to primate | | |
|---------------------------|----------|------------------------|
| Species | Attempts | Successes ¹ |
| <i>Saguinus Geoffroyi</i> | 32 | 4 |
| <i>Aotus trivirgatus</i> | 25 | 0 |
| <i>Ateles fusciceps</i> | 5 | 0 |
| <i>Alouatta villosa</i> | 2 | 0 |
| <i>Cebus capucinus</i> | 1 | 0 |
| Totals | 65 | 4 |
| Primate to primate | | |
| <i>Saguinus Geoffroyi</i> | 1 | 0 |

¹ Parasites seen for at least three successive days.

One attempt to transfer the infection by blood from one marmoset to another was unsuccessful.

In one case the blood film from the human donor showed gametocytes 5 days after his blood was inoculated into a marmoset. The blood film from the marmoset also showed gametocytes on the same day. The gametocytes reached a higher and earlier peak, 270 per mm³, in the marmoset but disappeared sooner than in the donor. One hundred and ninety-six *Anopheles albimanus* mosquitoes were fed on the marmoset on the days of gametocytemia. Subsequent dissections of 82 mosquitoes after 6 to 20 days of incubation at 76 ± 2 F revealed no infections.

DISCUSSION

Marmosets are not known to have natural malarial infections (Dunn and Lambrecht, 1963; Porter et al., 1966). We previously reported that *S. Geoffroyi* would support transient infections of *P. vivax* (Porter and Young, 1966). We now report that this marmoset will also support infections of *P. falciparum* lasting up to 15 days. The small size, availability, and freedom from malarial infections of this and other marmosets should prompt additional attempts to infect them with *P. falciparum* as well as other human malarial.

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TABLE II. *Plasmodium falciparum* infections in *Saguinus Geoffroyi*.

| Number or monkey | Treatment or surgery | Inoculum (10 ⁶) | Prepatent period (days) | Patent period (days) | Parasitemia maximum | |
|------------------|----------------------|-----------------------------|-------------------------|----------------------|---------------------|----------------|
| | | | | | Per mm ³ | Day of patency |
| 700 | Splen ¹ | 251 | 1 | 15 | 4,600 | 6 |
| 705 | Imuran ² | 671 | 1 | 4 | 80 | 3 |
| 699 | Imuran ² | 671 | 1 | 6 | 22,660 | 2 |
| 701 | Imuran ² | 5 | 2 | 6 | 40 | 5 |

¹ Splenectomized.

² Azathioprine: Burroughs, Wellcome and Co., Inc.