

ANTHROPOPHILIC BLACK FLIES (DIPTERA:SIMULIIDAE) IN THE AMAZON NATIONAL PARK (TAPAJÓS) AND THEIR EFFECTS ON MAN

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Six excursions were made into Brazil's Amazon National Park (Tapajós) in 1978 and 1979 to study the behavior of man-biting black flies and their effects on people. This article reports the results of that study.

Introduction

The family of small biting flies known as the Simuliidae has received increased attention in Brazil since the discovery of onchocerciasis by Berzoti et al. in 1967 (1). In addition, simuliid flies, also known as black flies, *piuns*, and *borrachudos*, are responsible for vectoring the more widely distributed *Mansonella ozzardi*, another filarial parasite of man (2, 3). Besides transmitting pathogens, the bites of Amazonian black flies have been credited with causing a hemorrhagic syndrome in humans residing near Altamira along the Transamazon Highway on the Xingú River in the state of Pará (4).

In the vicinity of rivers such as the Xingú, which are capable of providing a habitat for larval simuliids, adult black flies may become numerous and pestiferous enough at certain times of the year to seriously interrupt both work and leisure activities (5). Within the Amazon National Park (Tapajós), the Tapajós River and its tributaries provide ideal conditions for *piuns* (*Simulium* spp.). The Amazon National Park (Tapajós) is one of several national parks located within Brazil's Amazon Basin.

In an effort to find out more about the periodicity and activities of anthropophilic

species in the park, to learn about these species' effects on people, and to conduct a general survey of zoophilic species, we began a study in August 1978 in conjunction with a general wildlife survey performed by the Brazilian Institute of Forest Development (*Instituto Brasileiro de Desenvolvimento Florestal—IBDF*). The results obtained—on biting activities, seasonal abundance, and effects on visitors and inhabitants of the park—are presented here.

The Study Site

The Amazon National Park (Tapajós) was created by federal decree in February 1974. Most of it (see Figure 1) is located in western Pará State. The park includes a million hectares consisting of primary forest, extensive waterways, and land reclaimed from small farms. Both the Tapajós River and the Transamazon Highway transverse the southeastern edge of the park. Specific descriptions of larval breeding sites will be presented in a companion paper (6).

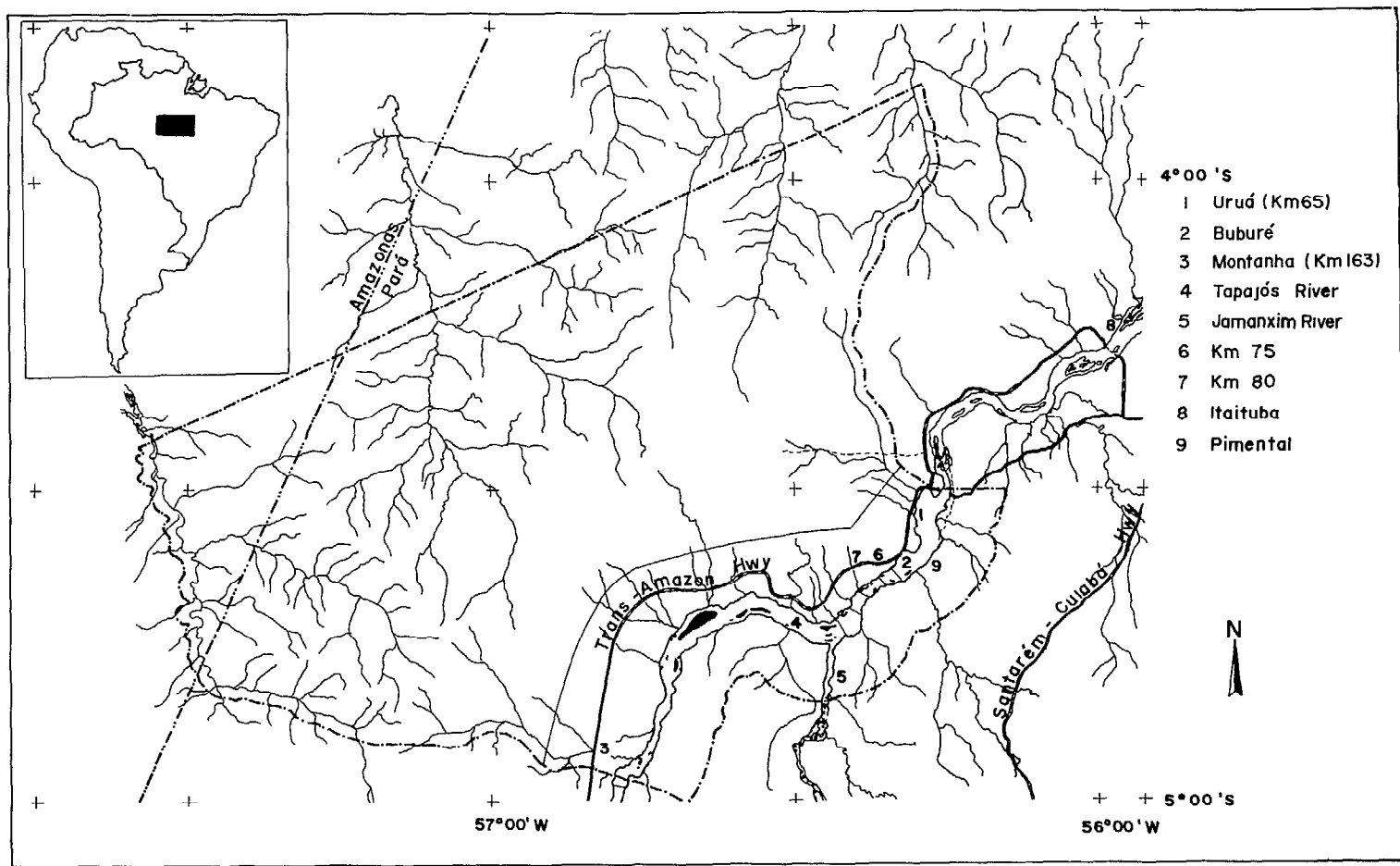
Materials and Methods

Six two-week excursions into the park were made between August 1978 and August 1979 to investigate the abundance and activity of anthropophilic Simuliidae.

Studies on the biting activity of these species were conducted with human bait at a small residential area of seven dwellings at Uruá on Km 65 of the Transamazon High-

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Figure 1. A map of the Amazon National Park (Tapajós) and surrounding areas. The dotted lines show the borders of the park and Pará State.



way. The subject was clad in shorts and was exposed for five-minute intervals from 5:30 A.M. until dark. From the time when the first biting activity occurred until 7:00 A.M., samples were taken every 15 minutes; from 7:00 to 8:30 A.M. they were taken every half-hour; and from 9:30 A.M. to 4:30 P.M. they were taken every hour. At the close of the biting cycle (from 5:00 to 6:30 P.M.), samples were again taken at fifteen-minute intervals.

After each collection the number of each species was tallied and the specimens were preserved—both dry and in 70 per cent alcohol—for future confirmation or identification. During each excursion to the park, three or four such whole-day collections were made. The numbers of flies collected during each excursion were subsequently totaled, averaged, graphed, and utilized for calculating relative simuliid abundance and species composition.

Comparison of biting activity in different habitats was made at four sites: on the Transamazon Highway, in a shaded area at the edge of the forest, 100 m into the forest (at Km 75), and at the intersection of the Transamazon Highway and a medium-sized stream (at Km 80). At each habitat, four five-minute collections were made in the late afternoon from a human subject wearing shorts. This was done on two separate days in June 1979 and once the following August.

The forest catches were made after walking 200 m into the woods and returning to the 100 m point. After the first five-minute collection and a five-minute wait, the second collection was made. Collections at mid-road on the Transamazon Highway and those in the shaded area at the edge of the forest were alternated.

Qualitative observations were also made at several locations along the Transamazon Highway—from Km 53 (Tracoá) to Km 163 (Montanha)—and on the Tapajós River within the boundaries of the park during each excursion.

Mean monthly rainfall and temperature data were obtained via IBDF for 1971-1977 from the Itaituba meteorological station.

Residents of the park were interviewed concerning allergic reactions and other effects caused by intensive feeding activities of *Simulium* species.

On one occasion peripheral blood samples were taken from two subjects, both of whom were long-term residents of the park and who had acted as bait subjects during the course of this study. The blood smears were air-dried and later stained using the Geimsa method, and were examined under high magnification (750-1000x).

Results

The only two species observed biting people during the six trips into the park were *Simulium guianense* or *pintoii* and *S. sanguineum* s.l.²

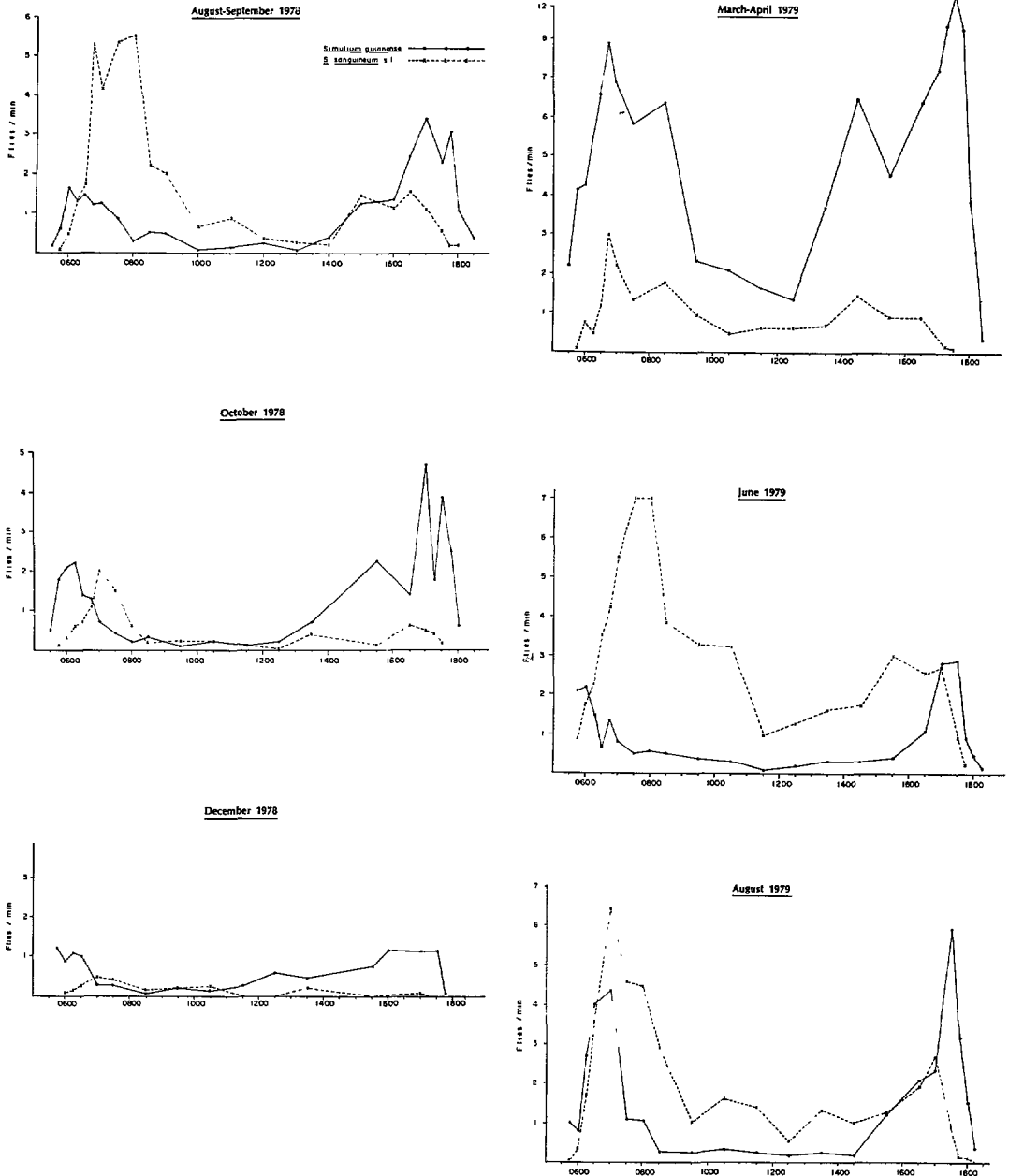
Figure 2 presents the averaged data collected during each excursion on the biting cycles of these two species. A bimodal biting pattern was apparent for both species throughout the year. *S. guianense* usually began 15 minutes earlier in the morning and persisted up to a half-hour longer in the late afternoon and early evening than did *S. sanguineum* s.l. Even during months when high levels of activity were observed, both species demonstrated a sharp late-morning to mid-afternoon decline in biting intensity.

S. guianense and *S. sanguineum* s.l. readily enter houses and bite indoors. *S. guianense* in particular is adept at taking indoor blood meals and will crawl inside clothing, especially up trouser legs.

The local residents report that during February another species makes an appearance for a month or so. According to their descriptions, this fly is probably *S. simplicicolor* Lutz, a zoophilic species which also bites man (7). The larvae of this species are found in

²The seminar on taxonomy of *Simulium amazonicum* and *S. sanguineum* s.s. and s.l. sponsored by WHO (Villa de Cura, Venezuela, 2-13 December 1979) concluded that two forms of *S. sanguineum* s.l. existed at Uruá; to avoid confusion, however, this article uses only the designation *S. sanguineum* s.l.

Figure 2. Biting patterns of *Simulium guianense* and *S. sanguineum* s.l. at Uruá, Pará, in the Amazon National Park (Tapajós) from August 1978 through August 1979. The charts show the average numbers collected at different times of the day.



large numbers in small to middle-sized streams throughout the park at certain times of the year (6).

Figure 3 shows the average and peak numbers of bites per minute that were recorded in different periods, together with corresponding rainfall data. According to 1971-

1977 data, the average annual median, minimum, and maximum temperatures were 26.0, 20.1, and 34.7°C. The proportion of each species in the combined whole-day collections is shown in Figure 4.

Table 1 presents data on the comparative biting rates of *S. guianense* and *S. sanguineum*

Figure 3. Average monthly rainfall, as measured at Itaituba, and seasonal abundances of *S. guianense* and *S. sanguineum* s.l. at Uruá, Pará.

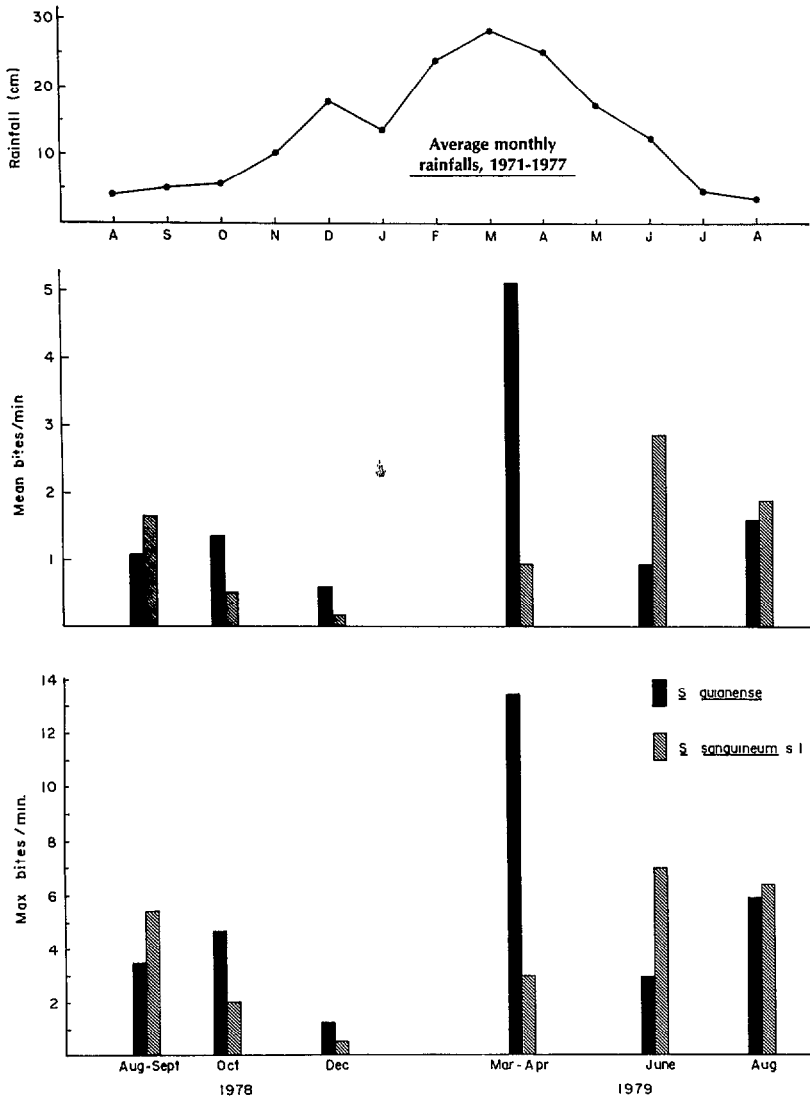
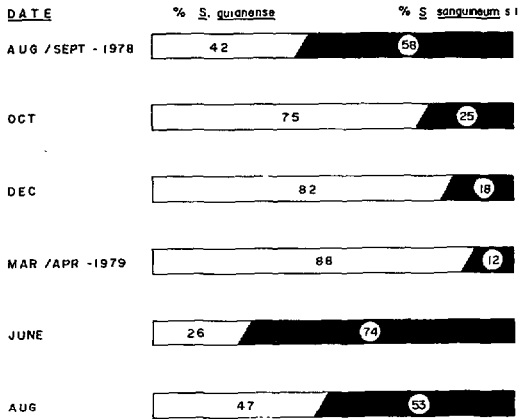


Figure 4. Percentages of the total *Simulium* population found to belong to *S. guianense* and *S. sanguineum* s.l. at different times from August 1978 through August 1979 at Uruá, Pará, Brazil.



s.l. in four different settings in June 1979. Similar results were obtained the following August, except that the biting activities of *S. guianense* were considerably more intensified in all but the forest setting.

Observations made throughout the year at other locations in the park indicated that cleared areas near waterways, especially inhabited ones such as Buburé, had a considerably higher number of host-seeking black flies than did Uruá. Flies were always encountered along the Transamazon Highway and were especially numerous where small streams crossed the highway.

Most of the residents of the park were quite tolerant of black-fly bites. Photograph 1B shows the typical lack of response to numerous bites. On occasion, however, strong allergic reactions were seen in resident children and visitors to the park. Photographs 1A and 1C show allergic reactions in a three-year-old boy and four-year-old girl. Neither were long-term residents of the park. Occasional eczema-like symptoms (which were preexisting in the boy) were exacerbated by *Simulium* bites and the subsequent reaction. Recently-arrived adults also responded allergically to the bites. Following a bite, a red weal would develop;

Table 1. Biting rates of *Simulium sanguineum* s.l. and *S. guianense* in four habitats along the Transamazon Highway in the Amazon National Park, Tapajós (June, 1979).

Locality	Mean number of flies \pm the standard error per five-minute sample	
	<i>S. sanguineum</i> s.l.	<i>S. guianense</i>
<i>Km 75:</i>		
Mid-road	40.3 \pm 16.90 (a)	2.8 \pm 0.63 (a)
Edge of forest	58.0 \pm 20.90 (ab)	3.0 \pm 1.47 (a)
In forest	2.7 \pm 2.67 (c)	0.5 \pm 0.29 (b)
<i>Km 80:</i>		
Road-stream crossing	120.8 \pm 23.0 (b)	3.8 \pm 0.75 (a)

Note: Means in the same column followed by the same letter in parentheses are not significantly different at the .05 level (Duncan's new multiple range test).

this would often be accompanied by swelling and elevated temperature in the vicinity of the bite. These symptoms usually subsided within 30 minutes, leaving a raised area and a hemorrhagic spot. In a few individuals, bleeding continued for a brief period of 10-15 minutes. Also, intense, sporadic itching lasted from a few days to over two weeks in certain sensitive people. Secondary infection often resulted from continual scratching. No systemic reactions were observed.

Although tolerant to the bites, local residents are deterred from both work and recreation when the biting activity of black flies, especially *S. sanguineum* s.l., is extremely high. Residents report that the skin develops a leathery condition as a result of receiving excessive bites at times when biting is especially intense.

No signs of blood-borne microfilaria or other pathogens were observed in the blood samples taken at Uruá.

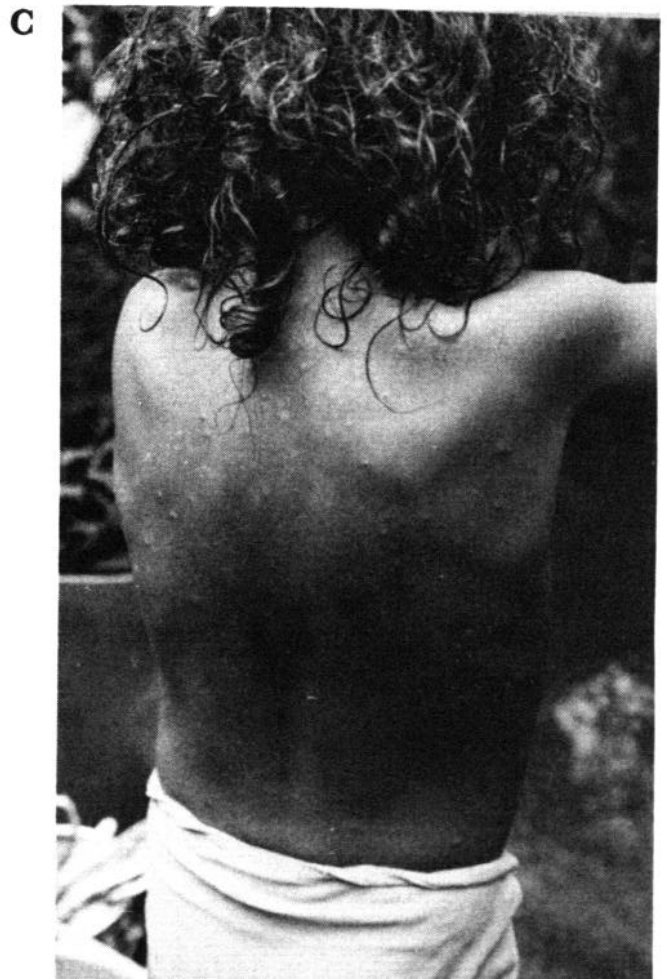
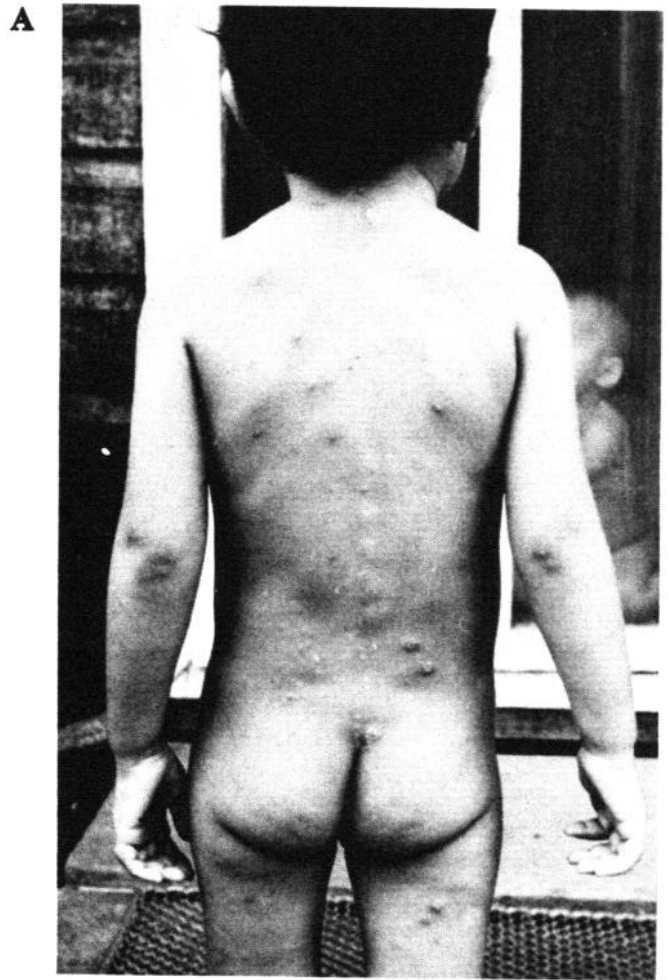
Discussion

The characteristic bimodal biting patterns observed throughout the year are a function of intrinsic factors subject to modification by

Photo 1. (A) Allergic reaction of a three-year-old boy to bites of *Simulium* flies, with exacerbation of preexisting eczema-like lesions.

(B) Upper arm of a woman about 50 years old who was a long-term resident of the Amazon National Park (Tapajós). Her arm displays numerous bites by *Simulium* flies.

(C) Allergic reaction of a four-year-old girl to bites of *Simulium* flies.



exogenous elements such as light intensity, temperature, and humidity (7). Both the maximum and mean bites per minute (see Figure 3) give a better indication of the abundance and seasonality of each species than can be determined readily from the graphic representation of biting patterns shown in Figure 2. Specifically, the mean number of bites per minute gives a more accurate index of relative seasonal abundance, while the maximum number of bites per minute better indicates the level of pestiferousness that a visitor to the park would encounter.

Rainfall appears to strongly influence the seasonality and abundance of both species. The initial sharp increase in *S. guianense* early in the year coincides with the period of heaviest rainfall. This may indicate possible breeding in smaller streams that come into being during the rainy season. It appears that the torrential conditions prevailing on the Tapajós River during the height of the wet season would not be conducive to development of large larval populations. Immatures of this species, however, were found in the Tapajós in moderately high numbers well into the dry season (August and September of 1978), when the river was lower and in a considerably less turbulent phase. The populations of *S. guianense* fluctuate independently of the rain cycle after their initial increase.

S. sanguineum s.l., on the other hand, increases in numbers as the rainy season is ending, at a time when major waterways are dropping and becoming less turbulent.

The discrepancy between the August-September 1978 and August 1979 collections—in terms of both abundance and species composition—is probably a function of the year-to-year variation in rainfall. 1979 was purported to be one of the wettest seasons on record, and this may have accounted for the greater abundance of both species that August.

The differences in local abundances of biting female *Simulium* flies that was observed within the park is probably due to the location of natural flyways, the distance from breeding sites, and locally attractive factors that would

tend to produce an aggregation of the flies. At Buburé, Montanha, and a construction site at Km 105, where the highest biting rates were observed, four common factors were noted: each site was next to a waterway; each was somewhat cleared; each had artificial structures; and in each case man and domestic animals were continually present. In areas that were similar, except that humans and domestic animals were not always present (at Km 80), biting rates were also high. In fact, at Km 80 one could be instantly attacked by large numbers of *S. sanguineum* s.l. upon arrival, indicating pre-aggregation, whereas at Km 75 the numbers increased gradually after the first 15 minutes. Km 75 was simply a stretch of the highway, with dense secondary vegetation on both sides, located three kilometers from the Tapajós River and five kilometers from the nearest stream—with no structures and usually no humans present.

Certain naturally clear areas adjacent to waterways, such as beaches, also act as aggregation points. These areas are often utilized by large birds, capybara, and tapir, presumably for access to water. Pre-aggregation of *Simulium* flies in such areas likely to be visited by host animals may be an adaptive means of insuring a blood meal where host animals are few.

It also appears that the Transamazon Highway is utilized as a dispersal flyway. Intersecting streams are also probably flyways, as well as nearby sources of emerging adults. Structures and the continual presence of animals apparently enhance aggregation but are not a prerequisite for it.

Research on *Simulium* dispersal and flight ranges by other investigators (8, 9) also indicates that streams and rivers are utilized as flyways. However, Thompson (9) found that roads were utilized very little and for only short distances.

A large collection-to-collection variance obscured any possible significant differences in the "mid-road" and "shaded edge of the forest" collections at Km 75. Although other researchers in the park have on occasion no-

ticed black flies biting within the forest, very little host-seeking activity is normally observed in this situation.

The allergic reactions that are most often seen in the park among sensitive individuals are commonly found wherever anthropophilic black flies prevail. In fact, black-fly bites have been associated with several cases of extreme allergic reaction and even death in humans (10-13). Some of the severe reactions and human fatalities attributed to black-fly bites have been reported from the Amazon Basin in Bolivia (12) and Brazil (4). In both regions hemorrhagic symptoms were observed; these almost invariably affected individuals who had recently arrived and occurred during periods of elevated black-fly activity. Similar reactions among visitors to the park should be anticipated by medical personnel in the Itaituba area.

The opening of the park, the easy access permitted by the Transamazon Highway, and the park's close proximity to the Itaituba Airport will increase the opportunity for interested individuals to view a somewhat

preserved section of the Amazon Jungle and its unique fauna. The potential hazard of extreme allergic reaction for people unaccustomed to high-density biting by black flies will likewise be increased. Unfortunately, during the months when the weather is most ideal for tourism in the park, either one or both of the anthropophilic *Simulium* species are active at moderate to high densities.

Sensitive people should wear protective clothing. Light-weight long-sleeved shirts and trousers tucked into socks or stockings will afford a certain degree of protection. When necessary, repellent applied to the remaining exposed areas will ensure near-total protection.

S. sanguineum s.l. and *S. guianense* have both been incriminated as vectors of *Onchocerca volvulus* (14), and although onchocerciasis and mansonelliasis have not been reported from the Tapajós area, their possible introduction should not be ruled out. In Northern Roraima, where both diseases are endemic among native Indians, the northern Perimeter Highway is on the verge of penetrating active foci.

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SUMMARY

Six two-week excursions into the Amazon National Park (Tapajós) were made between August 1978 and August 1979 to study the biting patterns and seasonal abundance of anthropophilic black flies, as well as the flies' effects on the human population within the park. The only two man-

biting species observed during this study were *Simulium guianense* and *S. sanguineum* s.l. Both species bite throughout the year in a bimodal pattern. That is, a morning peak is followed by a late-morning to mid-afternoon decline in biting activity, which in turn is followed by a second peak in late afternoon.

The largest numbers of biting *S. guianense* were recorded at the height of the rainy season. Host-seeking *S. sanguineum* s.l., on the other hand, were most numerous at the beginning of the dry season.

Of the various habitats studied, biting activity was most intense in partially cleared areas inhabited by humans near waterways, especially where streams and the Transamazon Highway intersected. These areas are probably attractive to the flies by virtue of their proximity to breeding sites and flyways. The presence of humans is not necessary, but it enhances the attractiveness of the areas

to host-seeking *Simulium*. Biting activity was least intense in dense vegetation.

Various allergic reactions were observed in individuals who had recently arrived at the park. Long-term residents, however, were extremely tolerant of numerous bites.

Protective clothing and repellents are suggested for allergic individuals. The possibility of introducing *Simulium*-vectored filariases into currently unaffected areas, because of increased access to foci in other parts of Brazil, should not be overlooked.

REFERENCES

- (1) Bearzoti, P., E. Lane, and J. Menezes. Relato de um caso de oncocercose adquirida no Brasil. (Reunioes científicas.) *Revista Paulista de Medicina* 70:102, 1967.
- (2) Cerqueira, N. L. Sobre a transmissão da *Mansonella ozzardi* (2 parts). *Jornal Brasileiro de Medicina* 1:885-914, 1959.
- (3) Moraes, M.A.P., M.M.R. Almeida, J. K. Lovelace, and G. M. Chaves. *Mansonella ozzardi* entre Índios Ticunas do estado do Amazonas, Brasil. *Bol Of Sanit Panam* 85:16-25, 1978.
- (4) Pinheiro, F. P., G. Bensabath, D. Costa, Jr., O. M. Maroja, Z. C. Lins, and A.H.P. Andrade. Haemorrhagic syndrome of Altamira. *Lancet* 1:639-642, 1974.
- (5) Pinheiro, F. P., G. Bensabath, A.P.A. Rosa, R. Lainson, J. J. Shaw, R. Ward, H. Fraiha, M.A.P. Moraes, Z. M. Gueiros, Z. C. Lins, and R. Mendes. Public health hazards among workers along the Trans-Amazon Highway. *J Occup Med* 19: 490-497, 1977.
- (6) Lacey, L. A., and V. Py-Daniel. Blackflies in the Amazon National Park (Tapajós): II. Larval habitats and distribution of the species. (In preparation.)
- (7) Lacey, L. A., and J. D. Charlwood. On the biting activities of some anthropophilic Amazonian Simuliidae (Diptera). *Bull Ent Res* 70:495-509.
- (8) Moore, H. S., and R. Noblet. Flight range of *Simulium slossonae*, the primary vector of *Leucocytozoon smithi* of turkeys in South Carolina. *Environ Entomol* 3:365-369, 1974.
- (9) Thompson, B. H. Studies on the flight range and dispersal of *Simulium damnosum* (Diptera: Simuliidae) in the rain-forest of Cameroon. *Ann Trop Med Parasitol* 70:343-354, 1976.
- (10) Papay, D., J. B. Szabo, and I. Tarjanyi. Public health consequences of the mass swarming of *Boopthora erythrocephala*. (In Hungarian with English summary.) *Parasit Hung* 4:181-188, 1971.
- (11) Jamnback, H. Recent developments in control of blackflies. *Ann Rev Entomol* 18:281-304, 1973.
- (12) Noble, J., L. Valverde, O. E. Eguia, O. Serrate, and E. Antezana. Hemorrhagic exanthem of Bolivia. *Am J Epidemiol* 99:123-130, 1974.
- (13) Owri, M., K. Saito, S. Matsui, and A. Ishii. Epidemiological study on black fly bites. *Jpn J Sanit Zool* 29:133-138, 1978.
- (14) Shelley, A. J., R. R. Pinger, M.A.P. Moraes, J. D. Charlwood, and J. Hayes. Vectors of *Onchocerca voluulus* at the River Toototobi, Brazil. *J Helminthol* 53:41-43, 1979.