

ASSOCIATIONS OF ARBOVIRUS VECTORS WITH GALLERY FORESTS AND DOMESTIC ENVIRONMENTS IN SOUTHEASTERN BOLIVIA¹

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In response to reported cases of yellow fever and possible dengue fever in a remote region of southeastern Bolivia in 1981, an entomologic survey of the affected area was conducted the following year. This article reports the results of that survey.

Introduction

Populations of *Aedes aegypti* (Linnaeus), the vector of dengue and urban yellow fever (YF), have reinfested some urban areas of Bolivia (1-3). While both dengue and YF outbreaks can occur in *Ae. aegypti*-infested cities and villages, the probability of a YF outbreak is perhaps greater, because that virus is present in a forest cycle throughout much of Bolivia (1, 4), while dengue is not known to exist in a forest cycle in the New World. Nevertheless, plaque-reduction neutralization tests conducted on paired sera from cases of febrile illness in an isolated population of Ayoreo Indians in the Rincón del Tigre area of Bolivia have demonstrated seroconversion to dengue virus. These cases of suspected dengue fever occurred almost concurrently with cases of YF during the first quarter of 1981. The tests were conducted in early 1982 at the Walter Reed Army Institute of Research in

Washington, D.C. The serologic results obtained aroused considerable interest, since reports from the Bolivian Ministry of Health indicated that there were no *Ae. aegypti* at Rincón del Tigre. Consequently, a trip was made to Rincón del Tigre in May-June 1982 to collect mosquitoes that could yield entomologic information and provide material for virus isolation efforts.

The specific aims of this project were (1) to conduct a survey of Rincón del Tigre for *Ae. aegypti* populations; (2) to develop a representative taxonomic collection of mosquito species in the area; (3) to collect mosquitoes for use in virus isolation attempts; and (4) to characterize the mosquitoes associated with domestic and sylvatic environments. This article reports the results of systematic collection of mosquitoes in the peridomestic and sylvan environments. Results of the taxonomic studies have been reported separately (5).

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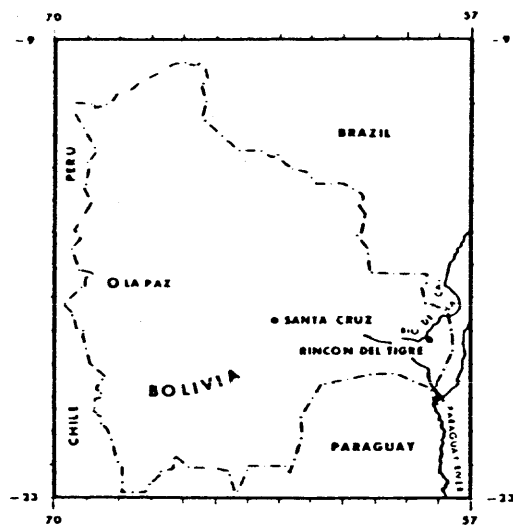
Materials and Methods

The Study Area

Rincón del Tigre is situated near the extreme eastern border of Bolivia (Figure 1) and provides the site for a Latvian Baptist Evangelical Mission that was established for the care of Chiquitano and Ayoreo Indians. The ecology of the area is transitional between the Amazonian tropical (evergreen seasonal) forest to the north and the tropical to semi-arid Gran Chaco of Paraguay and southern Bolivia. Very heavy rains occur in the hot wet season (December-May), but these are followed by extreme dryness in the cooler dry season (June-November).

Although the climate is generally considered tropical, southern winds sometimes bring freezing temperatures during the dry season. The altitude of the mission locale varies little, from a maximum of 232 meters above sea level to a minimum of 220; and the flat, poorly drained land becomes a virtual marshland during the wet season, when the rainfall averages about 90 cm. Scrub vegetation dominates most of the area, with taller forests (known as gallery forests) occurring along the edges of streams and rivers. These gallery forests, which are low and relatively open, range from single-canopy palm

Figure 1. A map of Bolivia showing the location of the Rincón del Tigre study area.



forests with few emergents to double-canopy deciduous forests. The surrounding countryside consists of an extensive tract of discontinuous marshland that covers much of eastern Bolivia and extends deep into Brazil. A more detailed description of the area has been presented previously (5).

The population at Rincón del Tigre (Photo 1)

Photo 1. An aerial view of Rincón del Tigre. Houses of the Ayoreo Indians are located at the upper right of the picture.

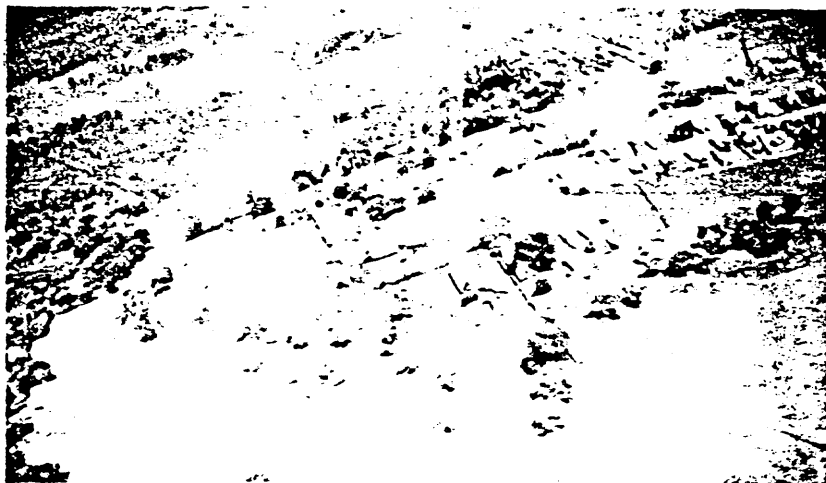
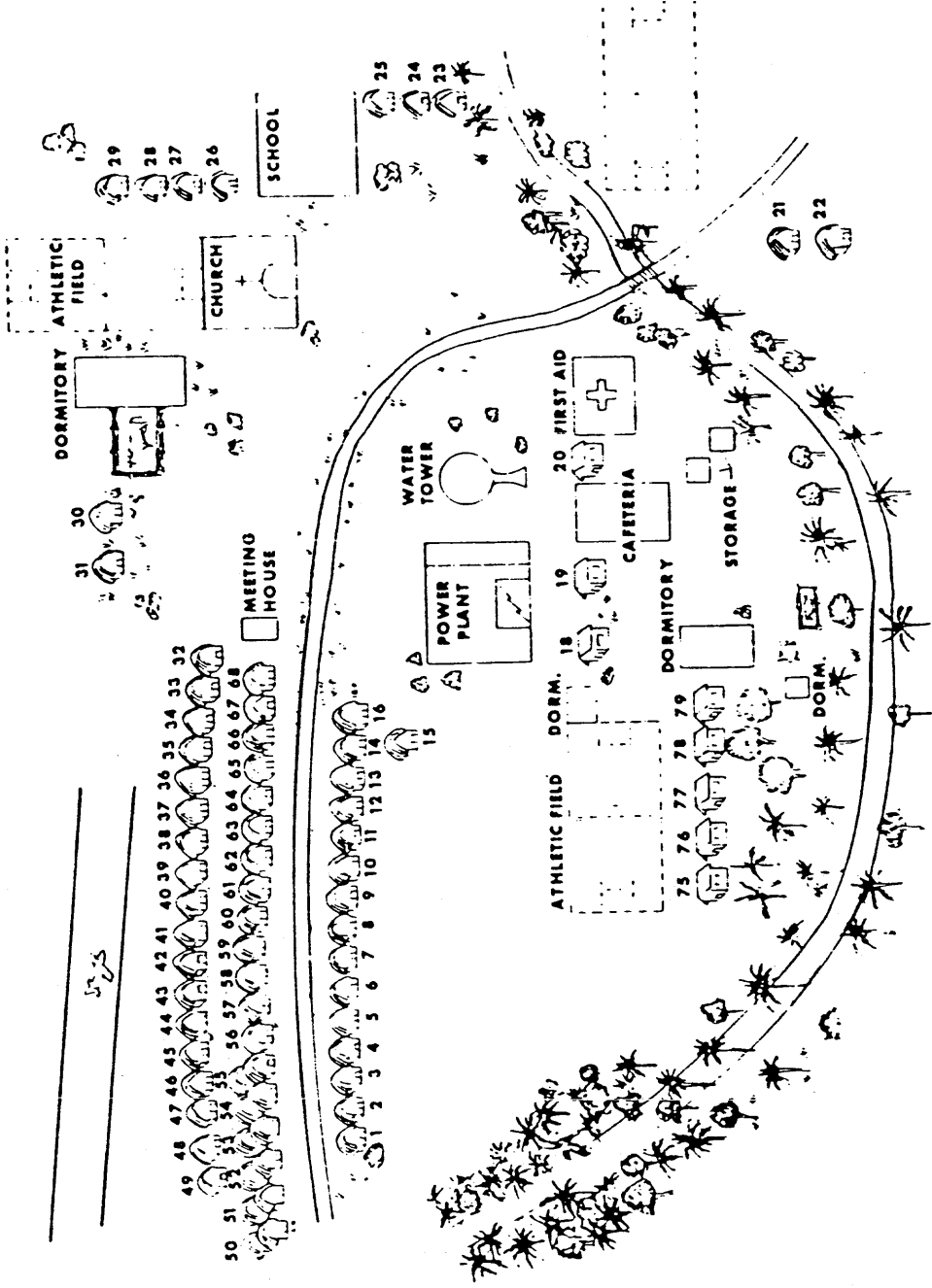


Figure 2. A schematic drawing of the village of Rincón del Tigre. Houses of Ayoreo Indians (numbered 1-15 and 32-68) are located to the left of the meeting house, and the houses of Chiquitano Indians (numbered 21-31) are located to the right of the meeting house.



is composed of Ayoreo Indians, Chiquitano Indians, and missionaries (a schematic map of the village is provided in Figure 2). The houses of the Ayoreo and Chiquitano Indians are constructed of palm thatch and mud. The Indians usually congregate outside in large social groups until late at night. Open fires are frequently maintained indoors to keep out mosquitoes; mosquito netting is not used.

Collection Sites

Mosquito collections were made at the mission for four days, primarily in Ayoreo houses. In addition, six gallery forest sites were examined for mosquitoes active in daylight hours. These six latter sites were as follows:

Site A was believed to have been the place where the first cases of febrile illness in the 1981 epidemic were contracted by Ayoreos prospecting for copper ore. The site was about seven kilometers south of the mission. The stream that produced the gallery forest at this site was small and, at the time of our visit, was dry. In general, the area seemed well-drained and comparatively dry. The forest was a deciduous type with a double canopy and very few lianas. The canopy

was not particularly thick, and considerable light penetrated to ground level. The soil was light brown to reddish and contained very little organic matter.

Site B was located four kilometers north of Site A along another gallery forest. Although the stream was larger than that of Site A and had running water, the surrounding terrain appeared as dry as that around Site A. The forest, composed principally of deciduous trees, had some emergent trees and a thick lower canopy. There were many aerophytes in the trees and very few lianas. The soil was light brown and low in organic matter.

Site C was located about 12 kilometers east and slightly north of the mission. The mosquito collections were made in a large forested area that is continuously inundated during the wet season (at the time of our visit it was almost dry). The area was flat, and the forest consisted of an equal blend of palm and deciduous trees. Tall emergent trees (such as those shown in Photo 2) were scattered throughout. The lower canopy was very dense, with little sunlight penetrating, and there was an abundance of lianas. The soil was black and relatively rich in organic matter.

Photo 2. Emergent trees viewed from the canopy of a gallery forest.



Site D was in a hilly area about four kilometers southeast of the mission. The collections were made among tall trees—in a valley between hills as well as on the hillsides. The lower canopy was thick and emergents were abundant. There was moderate light penetration. Within this forest area, the densest stand of palms was located in the valley near the stream. Aerophytes were common and there were few lianas. The tallest trees were found on the hillsides. The locality seemed to be well-drained, with the exception of swampy areas in the narrow valley. The soil was dark brown and contained some organic matter.

Site E was located eight to 10 kilometers northwest of the mission at a place called Curiche Bravo. Cases of febrile illness (including one or more deaths) had occurred at this site during the 1981 epidemic. The area appeared to be moderately dry, the forest being composed of deciduous trees and palms. This forest was reasonably tall, and the lower canopy was moderately thick. The soil was a red to brownish color and was low in organic matter.

Site F was three kilometers west of the mission and was basically a single-canopy palm forest. The growth of palm trees was extremely dense and the canopy was practically closed, with very little penetration of sunlight to ground level. There were a few emergent deciduous trees and very little undergrowth, the forest's large centrally located stream having subjected the area to frequent flooding. The eastern edge of this gallery forest was composed mostly of deciduous trees. The soil was dark brown with a moderate amount of organic matter.

Collection Methods

Human bait collections were made during the daytime in the mission village and at the six gallery forest sites. Collections were also made around sunset at the edge of the village, at two gallery forest sites (B and C), and in an abandoned house near Site F. The human bait captures were made from the exposed legs and arms of the collectors by means of oral aspirators and

small hand nets. The small hand nets were needed to capture some of the forest-dwelling *Sabethes* that are extremely difficult to capture by aspiration, even while they are feeding. However, these circumstances make it appear likely that some of the *Uranotaenia* collected at ground level were probably netted without actually biting. In any case, all the captured mosquitoes were blown into pint ice-cream carton holding containers and were subsequently killed, counted, and preserved in liquid nitrogen for later processing in the laboratory.

The human bait collections in the village were made in a total of eight houses. Paired indoor/outdoor collections were made for an entire day at four of the houses. Only indoor collections (all made during a single afternoon) were performed at the other four houses.

Collections of resting mosquitoes (Photo 3) were made at four dormitories and 52 houses. The collectors employed flashlights to search for the resting mosquitoes and captured them with oral aspirators and small hand nets. Specimens from the resting collections were processed like specimens from the human bait collections. The following series of resting collections were made:

- 1) During one day, hourly collections were made inside each of four houses (by two collectors per house) from 0800 to 1715 hours.

- 2) Over a two-day period, one-hour collections were made by single collectors at each of 48 houses.

- 3) A total of 67 man-hours were spent making resting collections in four dormitories.

Only human bait collections were made at the six gallery forest sites. Here the general collecting plan was to establish four two-man teams of collectors and to make collections at one-hour intervals. Following this plan, one member of each team climbed a tree and collected mosquitoes at heights of 12 to 20 feet, while the other team member collected mosquitoes around the base of the same tree at ground level. At the end of each hourly collection period, the team moved to a new tree and switched positions—so that the man formerly collecting at 12 to 20 feet was working at ground level and vice versa. The

Photo 3. A collector inside an Ayoreo Indian house preparing to collect resting mosquitoes.



collection containers used were gathered up at the end of each hourly collection period, and fresh containers for use in the next collection period were given to each collector.

Statistical Analysis

No statistical treatments were provided for data from collections conducted in and around the village. However, collections from the gallery forest sites were analyzed by calculating the standardized Index of Species Abundance (ISA) for each series of collections made at ground and canopy levels at each of the six sites (6). These indices provided a single numerical rating (from 0 to 1) of each species derived from that species' presence or absence in each collection and its relative numerical abundance. Patterns of diurnal host-seeking activity were analyzed graphically, using the geometric mean number of each species of interest that was obtained per man-hour of collection effort.

Results

The primary reason for making collections at the mission was to document the presence or

absence of *Ae. aegypti* populations in the mission's peridomestic environments. In all, a total of 58 houses occupied by Ayoreo and Chiquitano Indians were surveyed for *Ae. aegypti* populations; and approximately 2,400 mosquitoes were obtained through 250 man-hours of indoor resting and human bait collection effort. However, no *Ae. aegypti* were found in these collections. Furthermore, the entire area of the mission was searched for *Ae. aegypti* larvae with negative results (5).

The collections of resting adults made indoors consisted mainly (91%) of specimens of *Culex quinquefasciatus* Say. Other species obtained in the resting collections were *Ae. scapularis* (Rondoni), *Anopheles allopha* Peryassu, *An. darlingi* Root, *Cx. coronator* Dyar and Knab, *Mansonia humeralis* Dyar and Knab, and *Psorophora albigena* (Peryassu), as well as unidentified *An. (Nyssorhynchus)* and *Cx. (Melanoconion)* species. Anophelines were dominant in the indoor collections made with human bait and, excluding specimens of *Cx. quinquefasciatus*, they were also dominant types in the indoor resting collections.

A total of 22 man-hours was spent making human bait collections at sunset, from 1715 to

Table 1. Results of sunset collections made at 1715-1930 hours in May 1982 near the Rincón del Tigre village (at the edge of the forest) and at three gallery forest locations (Site B, Site C, and an abandoned house near Site F). The figures show the number of each mosquito species captured per man-hour of collection time.

Mosquito	Specimens collected per man-hour at:	
	Edge of forest near village (22 man-hours of collection time)	3 gallery forest sites (27 man-hours of collection time)
<i>Aedes fulvus</i>	0	0.07
<i>Ae. scapularis</i>	0.08	1.26
<i>Ae. serratus</i>	0	0.96
<i>Anopheles allopha</i>	4.8	0.19
<i>An. argyritarsis</i>	0.5	0.15
<i>An. darlingi</i>	0.13	0.33
<i>An. oswaldoi</i> group ^a	8.9	5.0
<i>An. rondoni</i>	0	0.11
<i>An. (Nyssorhynchus)</i>	0.46	0.0
<i>Culex coronator</i>	0.08	0.0
<i>Cx. quinquefasciatus</i>	0.17	0.0
<i>Cx. (Culex)</i>	0.08	0.19
<i>Cx. (Melanoconion)</i>	0.25	0.78
<i>Cx. (Microculex)</i>	0.21	0.33
<i>Mansonia juxtamansonia</i>	0.0	0.4
<i>Mn. humeralis</i>	0.25	0.0
<i>Mn. titillans</i>	0.38	0.11
<i>Psorophora albigena</i>	0.0	0.3
<i>Ps. cingulata</i>	0.04	0.07
<i>Ps. ferox</i>	0.0	0.04

^aKnown to consist of a mixture of *Anopheles rangeli*, *An. evansae*, and *An. strodei* with *An. rangeli* being the most common.

1930 hours, at the edge of the forest near the village. This yielded a total of 14 mosquito species (Table 1). Anophelines accounted for 91% of the total number collected.

As Table 1 indicates, anophelines also predominated among the mosquitoes collected around sunset (through 27 man-hours of collection time between 1715 and 1930 hours at the three aforementioned gallery forest sites).

The human bait collections made at the six gallery forest sites away from the village during daylight (0800 to 1800) hours at both ground and tree-canopy levels involved 463 man-hours of collection time and yielded approximately 4,000 adult mosquitoes. Species abundance indices derived from these collections (for both levels at each site) are shown in Tables 2, 3, and 4.

The ground and canopy level collections yielded comparable numbers of species (25 and

24, respectively). However, only about a third of these were frequently present in high population densities. Three of the eight or nine common species—namely *Aedes serratus* (Theobald), *Psorophora ferox* (Von Humboldt), and *Wyeomyia kerri* DelPonte and Cerqueira—demonstrated a distinct preference for feeding at ground level but also were frequently captured in the tree canopy collections. The species that were more commonly present and abundant at ground level were *Aedes oligopistus* Dyar, *Ae. scapularis*, *Anopheles darlingi*, *An. oswaldoi* group, and *Psorophora albigena*. Species that occurred in abundance only at the canopy level were *Haemagogus janthinomys* Dyar, *Sabethes albiprivus* Theobald, *Sa. belisarioi* Neiva, and *Sa. glaucodaemon* Dyar and Shannon. These relationships are shown clearly by a detailed comparison of paired canopy and ground collections from Sites A, B, C, and F (Table 4). Useful

Table 2. Indices of species abundance derived from gallery forest daytime collections (Rincón del Tigre, Bolivia, May 1982) made at ground level. These indices reflect both the numerical abundance of each species and the frequency with which that species was found at each collection site.

Mosquito	Indices of species abundance for collections at the following sites:								
	A	B	C	D	E	F ^b (20 May only)	F ^c	F ^c (20 May only)	F ^c
<i>Aedes fulvus</i>	.07		.3			.06			
<i>Ae. hortator</i>				.08	.07				
<i>Ae. oligopistus</i>	.31	.67	.19	.14	.45	.48	.62	.16	.31
<i>Ae. scapularis</i>	.18	.46	.83	.49	.64	.07	.05	.2	.38
<i>Ae. serratus</i>	1	.5	.84	.54	.95	.76	.66	.78	.57
<i>Anopheles allopha</i>				.26					
<i>An. argyritarsis</i>				.06				.14	.03
<i>An. darlingi</i>		.09			.66	.72	.55	.74	.44
<i>An. oswaldoi</i> group ^a		.25	.05	.05		.04		.92	.6
<i>Haemagogus janthinomys</i>	.16	.03	.07		.07				
<i>Mansonia titillans</i>		.06		.05	.26		.02		.19
<i>Orthopodomyia fascipes</i>		.07							
<i>Psorophora albigena</i>	.08	.03	.46	.06	.15	.37	.3	.22	.32
<i>Ps. cingulata</i>				.05					
<i>Ps. ferox</i>	.32	.27	.77	.91	.36	.76	.56	.21	.11
<i>Ps. saeva</i>	.06								
<i>Sabethes albiprivus</i>	.06	.07	.13		.4	.14		.05	
<i>Sa. belisarioi</i>	.13			.08					.13
<i>Sa. chloropterus</i>					.29	.1			
<i>Sa. glaucodaemon</i>			.16	.17	.17			.1	.26
<i>Uranotaenia calosomata</i>				.07					
<i>Ur. lowii</i>					.07				.02
<i>Ur. pallidiventer</i>						.05			.09
<i>Wyeomyia aphobema</i>					.07				.06
<i>Wy. kerri</i>					.14	.14	.56		.02

^aKnown to consist of a mixture of *Anopheles rangeli*, *An. evansae*, and *An. strodei*, with *An. rangeli* being the most common.

^bCollections made at the western edge of the gallery forest.

^cCollections made at the eastern edge of the gallery forest. No collections were made in the canopy at this location.

comparative statistics for seven selected species were obtained by calculating the ratio of the number collected per man-hour on the ground to the number collected per man-hour in the canopy (Table 5).

Observations on the diurnal patterns of host-seeking activity were compiled for eight of the more common species. No systematic subcollections were made during the sunrise or sunset periods, so data are available only for the period 0800 to 1800 hours. *Aedes serratus* was found to be active throughout this time interval, with peak activity occurring from 1000 to 1200. No distinct peak activity period was detected for *Ae. scapularis*, although this species did seem to be most active in the early morning. The activity pattern of *Psorophora ferox* was erratic and

appeared to be trimodal, with peaks at 0900, 1300, and 1600. *Aedes oligopistus* also showed a peak activity period around 0900, followed by a second more prolonged period of host-seeking from 1300 to 1500. The peak activity pattern for *Sabethes glaucodaemon* was unimodal, with the peak occurring around 1100, whereas the pattern for *Sa. belisarioi* was bimodal, with a mid-morning peak at 0900-1000 and a mid-afternoon peak at 1400. A primary peak activity period at 1300 was found for *Sa. albiprivus*, along with a secondary peak at 1600 and a minor peak around 1100. A unimodal peak activity period around 1600 was found for *Haemagogus janthinomys*. Activity data for the last two species are shown in Figure 3.

Table 3. Indices of species abundance derived from gallery forest daytime collections (Rincón del Tigre, Bolivia, May 1982) made at canopy level.

Mosquito	Indices of species abundance for collections at the following sites:						
	A	B	C	D	E	F ^a	F ^b
<i>Aedes fulvus</i>						.02	
<i>Ae. oligopistus</i>	.11			.12		.31	.2
<i>Ae. scapularis</i>			.13	.24	.56		.27
<i>Ae. serratus</i>	.64	.54	.21	.51	.89	.65	.67
<i>Ae. terreus</i>		.06		.1			
<i>Ae. vanemdeni</i>	.08						
<i>Anopheles darlingi</i>					.61	.29	
<i>An. oswaldoi</i> group ^a		.16		.14	.14	.13	
<i>Haemagogus janthinomys</i>	.43	.19	.29				
<i>Hg. leucocelaenus</i>	.18						
<i>Hg. spegazzini</i>				.05			
<i>Mansonia humeralis</i>		.06					
<i>Mn. tiillans</i>		.04					.1
<i>Orthopodomyia fascipes</i>				.06			
<i>Psorophora albigena</i>			.26	.1	.33	.07	.35
<i>Ps. ferox</i>	.13	.11	.8	.9		.75	.33
<i>Ps. saeva</i>		.04					
<i>Sabethes albiprivus</i>	.18	.4	.14	.37		.26	.3
<i>Sa. belisarioi</i>	.33	.28	.2	.08			
<i>Sa. chloropterus</i>					.08	.21	.17
<i>Sa. glaucodaemon</i>	.23	.42	.46	.08	.5		.1
<i>Uranotaenia calosomata</i>				.06			
<i>Wyeomyia kerri</i>						.58	.65
<i>Wy. petrocciae</i>				.18			

^aKnown to consist of a mixture of *Anopheles rangeli*, *An. evansae*, and *An. strodei*, with *An. rangeli* being the most common.

^bCollections made at the western edge of the gallery forest on 20 May 1982. Collections made on subsequent days were not adequate for purposes of comparison.

Figure 3. Geometric means of the numbers of *Sabethes albiprivus* and *Haemagogus janthinomys* captured in human bait collections made in gallery forests at Rincón del Tigre.

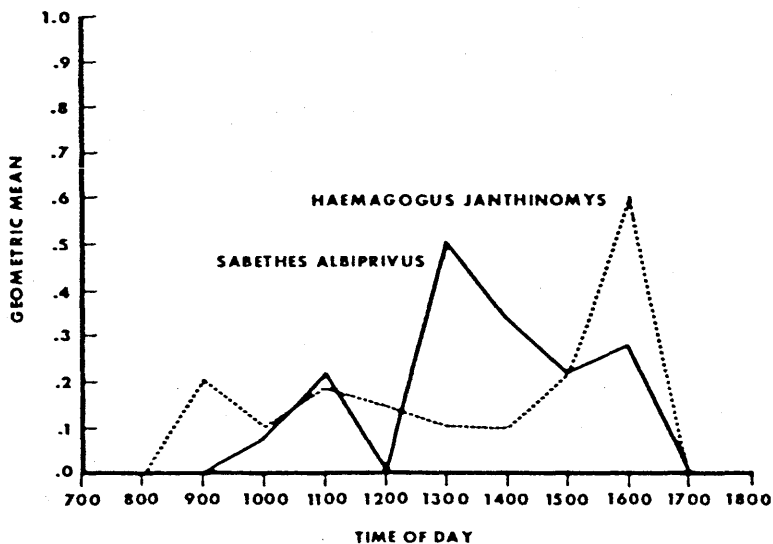


Table 4. Indices of species abundance derived from gallery forest daytime collections at sites A, B, C, and F made at canopy and ground levels.

Mosquito	Indices of species abundance for collections at the following sites:							
	A		B		C		F ^b	
	Canopy level	Ground level	Canopy level	Ground level	Canopy level	Ground level	Canopy level	Ground level
<i>Aedes fulvus</i>		.07			.06	.3	.02	.06
<i>Ae. oligopistus</i>	.11	.31		.67		.19	.31	.48
<i>Ae. scapularis</i>		.18		.46	.13	.83		.07
<i>Ae. serratus</i>	.64	1	.54	.5	.21	.84	.65	.76
<i>Ae. terrens</i>			.06					
<i>Ae. vanemdeni</i>	.08							
<i>Anopheles darlingi</i>				.09			.29	.72
<i>An. oswaldoi</i> group ^a			.16	.25		.05	.13	.04
<i>Haemagogus janthinomys</i>	.43	.16	.19	.03	.29	.07		
<i>Hg. leucocelaenus</i>	.18							
<i>Mansonia humeralis</i>			.06					
<i>Mn. titillans</i>			.04	.06				
<i>Orthopodomyia fascipes</i>				.07				
<i>Psorophora albigena</i>		.08		.03	.26	.46	.07	.37
<i>Ps. ferox</i>	.13	.32	.11	.27	.8	.77	.75	.76
<i>Ps. saeva</i>		.06	.04					
<i>Sabethes albiprivus</i>	.18	.06	.4	.07	.14	.13	.26	.14
<i>Sa. belisarioi</i>	.33	.13	.28		.2			
<i>Sa. chloropterus</i>							.21	.1
<i>Sa. glaucodaemon</i>	.23		.42		.46	.16		
<i>Uranotaenia pallidoventer</i>								.05
<i>Wyeomyia kerri</i>							.58	.14

^aKnown to consist of *Anopheles rangeli*, *An. evansae*, and *An. strodei*, with *An. rangeli* being the most common.

^bCollections made on 20 May 1982. Collections made at this site on subsequent days were not adequate for comparing canopy and ground level collections.

Table 5. Preferential feeding in the canopy or on the ground by seven selected mosquito species. These ratios are based on the actual numbers of each species collected per man-hour in the canopy and on the ground.

Species	Ratio of No. collected on ground to No. collected in canopy per man-hour
<i>Aedes serratus</i>	2.48:1
<i>Haemagogus janthinomys</i>	1:1.5
<i>Psorophora ferox</i>	4.05:1
<i>Sabethes albiprivus</i>	1:4.63
<i>Sa. belisarioi</i>	1:4.2
<i>Sa. glaucodaemon</i>	1:5.86
<i>Wyeomyia kerri</i>	1.34:1

Discussion

The foregoing results of these collections, all of which were made between 8 and 27 May 1982, verified the absence of *Ae. aegypti* populations at Rincón del Tigre. Moreover, interviews with residents gave no indication that this species had been present during the disease outbreak and had subsequently disappeared. Although this raises the possibility that the aforementioned cases of suspected dengue fever were transmitted by sylvatic vectors, we have been unable to confirm by virus isolation that cases of dengue fever occurred at Rincón del Tigre or that the virus, if present, was transmitted by sylvan mosquitoes.

The mosquitoes we collected were identified and were subsequently pooled for virus isolation. The total collection included over 6,400 specimens belonging to 58 species (mostly from the gallery forests), including species of *Haemagogus*, *Sabethes*, *Limatus*, *Wyeomyia*, *Aedes*, *Mansonia*, *Coquillettidia*, and *Psorophora*. Many of these species were collected as larvae or as adults in miscellaneous collections that have been reported separately (5).

Overall, the mosquito collections reported here were useful for describing mosquito faunal associations in the gallery forests (both at ground level and in the tree canopy), for describing the mosquito fauna associated with human habitations, and for defining the diel host-seeking patterns of the more common day-active species.

While several species were collected resting inside of village houses, *Cx. quinquefasciatus* was clearly the dominant species, accounting for 91% of the captured specimens. However, anophelines predominated in the indoor collections made with human bait. These findings suggest that *Cx. quinquefasciatus* is less inclined to feed during daylight and may be more difficult to catch in bait collections than are the anopheline mosquitoes. The predominance of the anophelines was even more pronounced in collections made at the forest edge around sunset. Nevertheless, the evidence provided by extensive indoor collections of resting adults leaves no doubt that *Cx. quinquefasciatus* was the primary anthro-

pophilic nocturnal mosquito in the environs of the village.

The yellow fever virus is maintained by urban (man-*Ae. aegypti*-man) or jungle (monkey-mosquito-monkey) transmission cycles. However, several mosquito genera, subgenera, and species have been incriminated as vectors of jungle yellow fever. Similarly, urban dengue is transmitted primarily (but not exclusively) by *Ae. aegypti*. But although sylvan cycles of dengue transmission occur in Peninsular Malaysia (7) and Africa (as attested by the work of R. Cordellier, M. Cornet, J. P. Digoutte, J. P. Hervy, and J. R. Roche, *Office de la Recherche Scientifique et Technique Outre-Mer, Institute Pasteur de Cote d'Ivoire, Institute Pasteur de Dakar*, cited as a personal communication in Rosen, 1983—8), no comparable cycle has been discovered in the New World. Nevertheless, viruses other than YF are maintained in the neotropics via monkey-mosquito-monkey cycles. (e.g., Mayaro virus is maintained by *Hg. janthinomys*—9), and the possibility of a sylvan dengue cycle becoming established should not be discounted.

After completing the collection regime in the village at Rincón del Tigre, we concentrated on obtaining information about a possible sylvan monkey-mosquito-monkey transmission cycle. Although the systematic collections at the six gallery forest sites yielded a total of 32 mosquito species, only a few of these species were commonly abundant. This finding is consistent with results obtained by another surveillance program in the Brazilian Amazon Basin, where only eight of 64 species were commonly abundant at a total of 12 study sites (10). In sum, horizontal and vertical distributions, as well as the numerical abundance of species collected at Rincón del Tigre, indicated that only seven species (*Ae. serratus*, *Hg. janthinomys*, *Ps. ferox*, *Sa. albiprivus*, *Sa. belisarioi*, *Sa. glaucodaemon*, and *Wy. kerri*) were promising candidates for the role of vector in a sylvatic virus transmission cycle.

Of these species, *Wy. kerri* seemed limited in distribution to the "Motacusal" (palm forest) habitat, which would minimize its role in virus maintenance over extensive and continuous

geographic areas. Furthermore, this species, like *Ae. serratus* and *Ps. ferox*, fed preferentially at ground level (see Table 5). Consequently, these three species were not likely to be primary vectors in a monkey-mosquito-monkey transmission cycle.

Of the remaining four species, *Hg. janthinomys* showed an appropriate distribution of feeding activity between the canopy and ground levels (preferential feeding in the canopy combined with substantial feeding near the ground). Such a preference for feeding in the canopy is conducive to efficient transmission of virus to monkeys, while willingness to seek hosts at ground level could involve humans as well. Also, comparing the six gallery forest sites, we found the densest populations of *Hg. janthinomys* at the site (Site A) where the first cases of febrile illness were apparently contracted. In addition, it should be noted that the diurnal host-seeking pattern of *Hg. janthinomys* populations at Rincón del Tigre was essentially identical to that found for populations of this mosquito at Belterra, Brazil (9). Finally, the three species of *Sabethes* showed more pronounced preferences for feeding in the canopy. Thus, these species could be primary vectors of virus to monkeys, but are less likely to transmit virus to humans.

In addition, our studies provided supplemental evidence that the vertical distribution of host-seeking populations of *Hg. janthinomys* varies from one geographic area to another, and that this variation may be due to differences in the height and density of forests. Such effects are important, since even subtle differences might dramatically alter the role of a canopy-associated mosquito as a vector of YF or other arboviruses to man.

Differences in vertical *Haemagogus* distributions due to geographic location or forest conditions have been noted by other investigators. Separate populations of *Hg. janthinomys* in Panama and in Belterra, Brazil, showed marked

preferences for feeding in the tree canopy (9, 11). However, collections of mosquitoes associated with gallery forests in Central Brazil demonstrated that the numbers of *Haemagogus* (probably *Hg. janthinomys*) collected in the tree canopy and at ground level were essentially the same (12). These differences could have been due to environmental factors because the gallery forests in the latter study were relatively low and open, whereas the forests in Belterra and Panama were taller and thicker.

The gallery forests at Rincón del Tigre, which were also low and relatively open, yielded a standardized ratio of ground:canopy host-seeking activity for *Hg. janthinomys* of 1:1.5, indicating moderate preference for feeding in the canopy. Similar calculations with data from the collections made in gallery forests in Central Brazil (12) gave similar ratios. In contrast, the ground:canopy host-seeking activity ratio calculated with collection data from Panama (based on collections made in tall thick forests) was 1:2.7 (11).

Although *Hg. janthinomys* is considered the primary vector of jungle yellow fever, isolations of YF virus have been obtained from pools of *Aedes*, *Sabethes*, and *Haemagogus* mosquitoes (13). Furthermore, outbreaks have occurred in areas where populations of *Hg. janthinomys* were not found. For example, studies made during an outbreak of yellow fever in Caranavi, Santa Cruz, Bolivia, during 1963 revealed the presence of *Sa. chloropterus* and *Hg. leucocelaenus* populations but no specimens of *Hg. janthinomys*. Females of both *Sa. chloropterus* and *Hg. leucocelaenus* were reported within houses at Caranavi (4). At Rincón del Tigre, however, no *Sabethes* or *Haemagogus* were collected inside houses, and *Hg. janthinomys* was present in the gallery forests. Therefore, we can reasonably conclude that this latter species was the probable primary vector involved in the Rincón del Tigre outbreak of jungle yellow fever.

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SUMMARY

Collections of domestic and sylvan mosquito populations were made at Rincón del Tigre, Bolivia, from 8 to 27 May 1982, in response to concurrent outbreaks of yellow fever and suspected dengue fever among Ayoreo Indians during the first quarter of 1981. No *Aedes aegypti* were detected. Sylvan vectors of yellow fever virus, encountered in the area's gallery forests, were probably responsible for the human cases of yellow fever.

Despite previous serologic evidence of dengue virus infections at Rincón del Tigre, no isolates or additional evidence indicating the presence of dengue virus was obtained. This article reports observations about the mosquito fauna associated with the domestic and sylvan environments and provides a detailed account of diurnal host-seeking activity patterns of the more abundant species attracted to human bait.

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WHO CANCER PAIN-RELIEF GUIDELINES FOUND EFFECTIVE

A report presented 11 December 1984 at an international conference on cancer pain management held at WHO Headquarters in Geneva indicated that a Japanese trial of WHO pain management guidelines had yielded encouraging results. According to the report, 87% of 156 cancer patients treated in accordance with the WHO guidelines received "complete relief" from their pain, 9% received "acceptable relief," and the remaining 4% received "partial relief."

The tests producing these results were carried out in 1983-1984 by Dr. Fumikazu Takeda at Japan's Saitama Cancer Center north of Tokyo. The ages of the patients treated ranged from eight to 83 years. Most were suffering from gastrointestinal cancer, but cases of lung, head and neck, and breast cancer were also prevalent. The cancers involved had spread in 80% of the patients, and about two-thirds of the patients reported that pain was severe before the cancer therapy commenced. Other tests relating to the WHO guidelines are being carried out in India, Italy, and the United States.

These WHO pain management guidelines were developed in an attempt to instruct health personnel who are not specialists in pain treatment about how to control most cancer pain by making appropriate use of a few potent drugs. They call for administering pain-killing drugs regularly at fixed intervals, in contrast to the general practice of administering them only "as required" in time of pain. They also call for using drugs of progressively increasing potency—going from nonnarcotic drugs to mild narcotics to strong narcotics—until the patient is pain-free. Thus, if one drug proves ineffective a stronger drug rather than merely a different drug is prescribed.

The four-day international conference at which the Japan results and a wide range of other research findings were presented was part of a recent WHO initiative to raise public awareness of a largely neglected problem in cancer care, the management of pain. Worldwide, one person in 10 dies of cancer; and according to WHO information, over half of all cancer patients suffer needlessly from pain—because cancer specialists are not adequately trained in pain management and because pain-killers are not adequately used. What therefore appears needed is a concerted effort to apply what is already known in order to bring relief to millions of cancer pain sufferers around the world.

Source: World Health Organization, Press Release WHO/20, 11 December 1984.