



VECTOR BIOLOGY & CONTROL

Vector Biology & Control Project
1611 North Kent Street, Suite 503
Arlington, Virginia 22209
(703) 527-6500

Telex: 248812 (MSCI UR)
Cable: MSCI Washington, D.C.

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**VECTOR BLACKFLY SURVEY IN THE UNIROYAL
RUBBER PLANTATION AT THE LIBERIAN
AGRICULTURAL COMPANY - 1986**

by

**David J. Fryauff
James E. Childs, Sc.D.**

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Authors

Mr. David J. Fryauff is a doctoral candidate (Sc.D.) in entomology and parasitology at The Johns Hopkins University.

James E. Childs, Sc.D., is an assistant professor in the Department of Immunology and Infectious Diseases at The Johns Hopkins University.

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I. EXECUTIVE SUMMARY

Between December 8-20, 1986, a survey of vector blackflies was conducted in the Uniroyal Rubber Plantation of the Liberian Agricultural Company in Grand Bassa County, Liberia. This survey was undertaken for Medical Service Consultants and the A.I.D. Vector Biology & Control Project for the purpose of selecting capture sites for man-biting blackfly vectors of onchocerciasis, and was intended to provide the basic information from which to design a long-term survey of onchocerciasis transmission by these vectors.

A total of 51 potential sampling sites was examined. Each site was evaluated in terms of suitability for blackfly breeding (rapid current, turbulence, perennial flow, available larval substrates, and presence of Simulium damnosum s.l. larvae), evidence of frequent human use, and acknowledgement of blackfly biting activity at the site by local residents. Sites considered to be most productive in terms of vector blackflies were selected and sampled by means of biting catch for at least seven continuous hours. Note was also made of the numbers of men, women, and children utilizing the sites during each hour of the blackfly sampling period. Captured blackflies were identified and dissected to determine reproductive status and parasite content.

On the basis of blackfly landing/biting rates, central, peripheral, and outside plantation control sites were identified which may serve as permanent stations for monitoring onchocerciasis transmission by local vector populations. At these prospective sites blackflies were collected by means of biting catch over a period of 315 sampling hours. Landing/biting rates for sites within the plantation ranged from 0 to 7 flies/man/hr., and averaged 2 flies/man/hr. Landing/biting rates for control sites outside the plantation ranged from 0 to 17 flies/man/hr., and averaged 8 flies/man/hr.

Vector biting activity was attributed almost exclusively to Simulium yahense. S. sanctipauli, the only other vector species identified in our collections, was found at only a single site on the St. John River. Dissection of 579 blackflies captured within the plantation revealed high rates of parity, infection, and infectivity. Overall infection rates for these flies averaged 37.5%, while infectivity averaged 7.3%. Dissection of 279 blackflies captured from control sites outside the plantation also revealed high rates of parity, infection, and infectivity, although these rates were slightly lower than those of the plantation. Overall infection rates for flies from control sites averaged 25.4%, while the infective rate for these flies averaged 6.4%.

Plantation and control sites considered to be suitable for blackfly breeding were surveyed for the presence of vector blackfly larvae. Although a number of plantation sites were considered to provide ideal conditions for blackfly breeding, vector larvae were collected from only the Slo River, which forms the eastern boundary of the plantation. Vector larvae were collected from control sites on the St. John River, the Timbo River, and at Yoni Creek.

Landing/biting rates and rates of infection/infectivity for blackflies collected from within the plantation during this short period of survey were sufficiently high to suggest that ivermectin treatment of the resident human population should result in a significant and measurable decrease of Onchocerca volvulus transmission by vector blackflies.

II. INTRODUCTION AND GENERAL DESCRIPTION OF SURVEY AREA

The rationale for this trip to the Uniroyal Rubber Plantation (URP) of the Liberian Agricultural Company (LAC) was to locate sites within and around URP that could serve as blackfly collecting sites for monitoring the effects of wide-scale human treatment with ivermectin on the transmission dynamics of onchocerciasis.

The specific objectives were as follows:

1. Locate and define 10 sites in and around the Uniroyal Rubber Plantation (URP) at the Liberian Agricultural Company (LAC) to serve as blackfly collection sites for determination of the intensity of Onchocerca volvulus transmission.
2. Sample different locations for the presence of blackflies and establish crude comparative indices of landing/biting rates based on man-hour collection schedules (obtained by daily sampling at all 10 sites).
3. Determine the species composition of landing/biting flies at each location and subsequently establish the infection/infective rates for blackflies harboring O. volvulus larvae.
4. Estimate, from selected sampling locations, the logistic requirements of weekly blackfly survey in terms of mileage, gasoline cost, and driving time.

This survey work was conducted from December 8-17, 1986 by James E. Childs, and from December 8-20, 1986 by David J. Fryauff.

The URP is located in the rain forest zone of Liberia (5°58' - 6°9' north; 9°44' - 10°50' west) approximately 130 miles southeast of Monrovia, and 92 miles by car from Robertsfield International Airport and the LIBR. The plantation was previously described (M. Trpis, personal communication) as consisting of 32 km² of a homogeneous monoculture of rubber trees (Hevaca braziliensis). The URP has since added approximately 11,362 hectares of newly planted rubber trees to the northeast (designated Estate 3), and an additional 2,470 hectares to Estate 4 in the southeast. The Slo River now forms the northeastern perimeter of the plantation.

The plantation consists primarily of a uniform biotype defined by mature rubber stands. Other habitats, however,

constitute a significant portion of the plantation. The new Estate 3 is comprised of distinctly smaller trees (DBH 5-15 cm.) which are just being tapped, or will be tapped within the next few years. The southeastern plantation around Food Crop Camp (#23, #24 on map) is composed of grasslands, small islands of secondary forest growth, and overgrown cleared land planted with legumes to depress weed growth. A significant number of cattle are grazed here as a food source for plantation workers. The rivers, streams, and creeks of the plantation are bordered by secondary growth forest and dense bush, and cultivation of rubber ends some 20-50 m from the watercourse, depending on elevation gradients.

The climate of URP is dominated by distinctive wet-dry seasons in which monthly rainfall may vary more than 50-fold (Appendix 1). Severe dry seasons generally occur from November through March (C. S. Ong, personal communication).

The human population of the plantation is currently estimated at 16,000 - 20,000, of which 3,500 are employed as workers (Dr. P. N. Williams, personal communication). Plantation employees and relatives live in 63 camps consisting of 3 - 33 houses, with approximately 5 persons per house (Dr. P. N. Williams and Mr. T. Gboweh, personal communication; Appendix 2). The approximate locations of these camps are shown on the small-scale map (Figure 1). The working population is composed of 77% tappers, 8.6% clerks, 8.6% factory workers, 3.9% drivers, and 1.7% hospital workers. The tribal composition of plantation employees is approximately 40% Bassa, 35% Kpelleh, 20% Gissie, and 5% Grebo, Mano, and/or Lorma. It is estimated that 60 - 70% of the plantation employees reside within the plantation boundaries for a minimum of 1 - 2 years. Many of these individuals will live at URP for 15 - 20 years, and a rough estimate of mean residence time is 5 - 10 years (Dr. P. N. Williams, personal communication). The daily salary for unskilled workers starts at \$3.50 (Liberian) per day.

Three major rivers or streams and their feeder creeks dominate the plantation. The New Cess River flows on the northwestern periphery and forms a portion of the north and west boundary. The Slo River flows on the northeastern and eastern periphery of the plantation and forms a portion of the north and east boundary. The Chran Ba Creek forms down the center of the plantation, but does not become a rapid, large river (> 5 m width) until it reaches the southern periphery near Suati Camp (map #15). The distribution and flow of large river systems to the east, west, and south of the plantation resulted in a dearth of significant streams in the north-central region of the plantation during dry season. Most watercourses in the north-central region of URP are small (1 - 3 m wide), slow, and can dry

under seasonal conditions. The only notable exceptions in the northern region of the plantation are the New Cess River, and one of its major feeders, locally termed Keene Creek. The recommendation for study locations reflects the drainage pattern of the plantation. The St. John River, one of Liberia's largest rivers, flows to the west of the Plantation, and the area adjacent to this river is densely forested, sparsely populated, and distinctly different from plantation habitat. Sporadic collections of adult man-biting blackflies and S. damnosum s.l. species larvae suggest that the vector populations along the St. John River are compositionally different (and presumably vectorially less significant) from those found within the plantation (S. sanctipauli vs. S. yahense, respectively). For these reasons, control sites along smaller stream systems of the north, east, and south were examined in greater detail to control for conditions found in the plantation.

An intricate network of roads crisscrosses the plantation (Map, Figure 1), providing access to all camps and most collection sites. These roads should be passable during the wet season (URP drivers, personal communication). Unfortunately, maps (either URP or USGS) were not yet available which provide details of the new estate areas in the north and south of the plantation. Rough estimates of road systems and distances were recorded, and Mr. Gerhart expects detailed maps to be available within the year (currently being produced by URP). No recommended collection sites were located in the newly-planted northeastern portion of the plantation, obviating the need for detailed maps at this time. This region contains only four sparsely inhabited camps at this time, and should not become of significant epidemiologic interest until active collection of latex commences in the next few years. A set of USGS maps covering URP-LAC and control sites were submitted with this report as Appendix 3. They are on file at the VBC Project office.

III. FINDINGS

Sites Surveyed

A total of 51 sites (43 within the plantation, 8 outside controls) were examined with regard to size, water flow, water clarity, proximity to human habitations, evidence of human use, and potential for perennial or seasonal breeding of blackfly vectors. Table 1 summarizes these findings and in addition indicates the major watercourse for the site, the reference location within (or outside) the plantation, and the designated map number as shown in Figure 1. The type of human uses associated with each site, as obtained by interview or by observation, are also listed in Table 1.

The map numberings were assigned in rough chronological order of visitation and indicate nothing about the suitability of a site. The sites at which blackfly adults or larvae were collected, and which we recommend for inclusion in subsequent studies, are examined in detail below. Table 1 provides a useful summary for future surveys of URP-LAC in different seasons, and with Figure 1, will provide an excellent guide to plantation watercourses and camps for collection of epidemiological data.

Recommended Sites

The sites recommended for inclusion in the long-term transmission study are listed in Table 2. Map numbers and reference locations are reiterated, and in addition, information on the Man Hour Index (MHI) -- an indication of blackfly landing/biting rates per man hour, and the Human Index -- an indication of human use per site per hour, are shown. Locations identified as having significant landing/biting rates during our December visit are underlined and strongly recommended. Sites we believe to have significant potential for seasonal transmission activity are included in Table 2 but not underlined. We strongly urge additional seasonal surveys of these sites as they will provide more uniform coverage of the entire plantation.

The recommended sites shown to have significant MHI's and their reference locations are listed below. Potential sites considered to be of special interest for further examination during other seasons are marked with an asterisk.

Central Plantation Area

6-Old Camp #1
 6-New Camp #1
 Gissie Camp
 Djueh Camp #1*
 Djueh Camp #2*
 Bonaza Camp*
 Zia Camp*

Peripheral Plantation Area

Raymond Camp
 Suati Camp
 Huygen Camp
 Canoe Crossing #1*
 15 Houses*

Control Sites

Logging Rd. Bridge
 Josephbli
 Koko David Town
 Sambli*

Photographic slides of these locations and other objects of interest were submitted with this report, and are on file at the VBC Project office. Descriptions of these slides are given in Appendix 4.

Indices were obtained via daily counts by field assistants (Daily collection/observation form included as Appendix 5). Daily activity of blackfly landing/biting and human use were typically bimodal, with peaks in the morning and late afternoon. Only overall hourly averages are shown. The sampling times at given sites reflect our attempt to adequately define sites of special significance. Overall, we believe our plantation sites and control sites are well-matched with regard to the Human Index (Table 2), and comparative sizes of watercourses (Table 1). The MHI indicates higher landing/biting rates at control sites, and this should be regarded as a positive finding that will ensure adequate collection of data from locations outside the plantation area.

Species Identification and Dissection Results

A summary of adult blackflies identified and dissected for the presence of parasites indistinguishable from O. volvulus is shown in Table 3. These results, although based on a small, highly seasonal sample, indicate three major findings:

1. Blackfly vectors are present in moderate to large numbers at most of the sites sampled by man-biting catch within URP-LAC and at outside control sites.
2. Except for those flies captured at the St. John River, the vector population is composed exclusively of S. yahense.
3. Blackflies in the plantation and control regions are frequently infected and harbor moderately large worm burdens (Plantation L2 range: 1 - 21, mean = 3.2, S.D. = 3.2, N = 182; Plantation L3 range: 1 - 26, mean = 4.2, S.D. = 4.7, N = 37; Control L2 range: 1 - 8, mean = 2.4, S.D. = 1.9, N = 58; Control L3 range: 1 - 15, mean = 4.2, S.D. = 4.0, N = 19) of parasite larvae indistinguishable from O. volvulus.

These results probably reflect the hyperendemic nature of onchocerciasis at URP-LAC, although detailed collection of epidemiological data on human infection and disease are essential. The major vector of the plantation is the highly anthropophilic species, S. yahense. The number of flies present and the extremely high infection rates obtained indicate that a significant reduction in microfilaridemia in the human population of the plantation should be reflected in corresponding decreases in worm loads and infection rates of the vectors. These limited entomological and parasitological observations indicate that URP-LAC is a uniquely qualified area (M. Trpis and D. Fryauff, personal communication and published results from Firestone Rubber Plantation) in which to conduct research on the potential for interrupting transmission via ivermectin treatment. The extremely high infection rates of flies are probably due to the dense, highly-infected human population and seasonal conditions that inhibit vector breeding and resulted in an older age distribution of flies (and hence greater probability of parity and infection) during our sampling period. Although the presence of parasite infections of animal origin could not be excluded, we believe the high rates of infection are most likely due to O. volvulus. It is significant to remember that flies were collected on humans, demonstrating an anthropophilic tendency, and that large numbers of cattle were found only in the southeastern portion of the plantation. Conditions within the plantation discourage habitation by animals (including birds) other than those kept domestically by people living in the camps.

Survey of Breeding Sites for Vector Larvae

Plantation and control sites considered to be suitable for blackfly breeding were surveyed for the presence of vector

blackfly larvae. Although a number of plantation sites were considered to provide ideal habitat conditions for the development of blackfly larvae, and did support larval populations of non-vector species (S. cervicornutum, S. unicornutum), vector larvae were collected from only the Slo River, which forms the eastern boundary of the plantation. The larvae collected from this watercourse were morphologically identified as S. yahense and S. sanctipauli. Vector larvae were collected from control sites on the St. John River (S. sanctipauli), the Timbo River (S. sanctipauli), and at Yoni Creek (S. yahense). An extensive investigation of the plantation's Chran Ba Creek in the vicinity of Suati Camp was conducted. Although this watercourse appears to provide ideal habitats for perennial breeding of S. yahense, we did not find any vector larvae. We believe that further larval survey will reveal the presence of S. yahense in this watercourse, and that seasonal climatic conditions (the onset of wet season in April - May) that generally produce large populations of vector blackflies should be considered.

Estimated Logistical Requirements of Weekly Blackfly Survey

The following rough summary of our daily mileage records for two vehicles indicates maximum expected daily mileage for future surveys:

Toyota long wheel-base diesel

Days of use = 10
Miles travelled = 776.4
Daily mean = 77.6

Toyota short wheel-base

Days of use = 12
Miles travelled = 1010.7
Daily mean = 84.2

The short wheel-base total includes three round trips (approx. 184 mi./round trip) from LIBR to URP-LAC. In future surveys, where exploration of new territory is limited, we expect that a maximum of 50 - 60 mi./day will be required. This estimate includes trips to control sites outside of URP-LAC.

Our total gas/diesel plus oil bill was approximately \$300 (\$297.95). Cost of gas/diesel averages approximately \$3.00/gallon, so we estimate using approximately 100 gallons. Based on total mileage for both vehicles (1787.1), we estimate an average of 17.87 mi./gal. This translates into a daily expected

operating cost of \$10/day for gasoline/diesel in future surveys. This estimate does not, and cannot, include the costs of major repairs to vehicles.

Crude estimates of distances between recommended sites within URP-LAC can be determined directly from Figure 1. Maximum driving time from the hospital/clinic to the northern boundary (15 houses) is 15 minutes, to the western boundary (Raymond Camp), 15 minutes, and to the southern boundary (Suati Camp), 25 minutes. Mileage from the clinic to the northern control site on the Slo River is approximately 22 miles. Mileage from the clinic to the southeastern control site at Koko David Town is approximately 14 miles. Walk-in time to the control site at Yoni Creek (Josephbli) is one hr. for a field assistant and requires crossing the Slo River by canoe at Map site #11.

Additional Comments

The conditions at URP-LAC are excellent and are conducive to long-term studies. Key plantation personnel, most notably Mr. Kenneth Gerhart and Dr. Noel Williams, are enthusiastic about the nature of this research, and went out of their way to aid our activities. The network of roads at URP-LAC ensures access to sites during all seasons, and the daily activities of the plantation require good maintenance of roads.

IV. RECOMMENDATIONS

We recommend the following:

1. URP-LAC should be considered a primary candidate location for investigating the potential for interrupting transmission of onchocerciasis via widescale human treatment with ivermectin.
2. Sites within URP-LAC, detailed above, should be established as long-term monitoring stations of blackfly landing/biting rates and corresponding human activity.
3. Efforts should be made to extend our initial survey to other sites of special interest, detailed above, during other seasons of the year to provide more uniform coverage of URP-LAC.
4. Sites outside of URP-LAC, detailed above, should be included as control locations for the long-term monitoring of blackfly landing/biting rates and corresponding human activity.
5. Efforts should be made to collect more detailed information on human infection and disease due to O. volvulus at URP-LAC and control sites before, during, and after ivermectin treatment.
6. Efforts should be made to initiate standardized diagnostic procedures for obtaining skin snips of plantation workers at the URP-LAC clinic, and to capitalize on this routinely collected source of information.
7. The personnel hired as field/lab assistants showed loyalty and interest in this project, and deserve consideration for jobs should a long-term study be initiated. Their names are as follows:

Solomon Gargar
Joseph Gbaa
Joseph Johnson
J. Makezoe Kpadyu
Rufus Monway
8. Copies of this report should be sent to Mr. Kenneth Gerhart and Dr. Noel Williams, URP-LAC, and to the USAID Mission, Monrovia, Liberia.

Table 1. Summary of characteristics of sites surveyed at URP-LAC and control regions with corresponding indications of human use. December 8 - 20, 1986.

LOCATION	MAP NO.	REF. LOCATION	WATERCOURSE	HUMAN USES	GENERAL DESCRIPTION
Gorzhon Camp #1	1	central	Chran Ba Ck.	---	1-2 m wide, slow flow, silty, poor vector breeding potential
Gorzhon Camp #2	2	central	Chran Ba Ck.	---	1-2 m wide, slow flow, silty, poor vector breeding potential
Budding Camp	3	NW periphery	Mani Ck.*	B	1-2 m wide, slow flow, clean, poor vector breeding potential
15 Houses	4	NW periphery	Keene Ck.*	F,L,D,F**	2-8 m wide, moderate-rapid flow, clean, nearby habitation, good seasonal breeding potential, frequent human use.
Shop/Factory	5	NW periphery	New Cess R.	B,L,F	6-8 m wide, moderate flow, clean, polluted below factory discharge
Raymond Camp	6	NW periphery	New Cess R.	B,L,D,F	6-8 m wide, moderate-rapid flow, clean, good perennial breeding potential
Small Cpd. (south)	7	central	branch of New Cess R.	B	1-2 m wide, slow flow, silty, poor breeding potential
Djueh Camp (east)	8	central	branch of New Cess R.	B	1-2 m wide, moderate seasonal flow, seasonal breeding potential
Djueh Camp #1	9	central	Neekpu Ck.*	B,L,F	8-10 m wide, sluggish, silty, nearby habitation, frequent use, seasonal breeding potential
Djueh Camp #2	10	central	Neekpee Ck.*	B,L,D	2-3 m wide, moderate flow, clean, dry season use, seasonal breeding potential
Canoe crossing #1	11	W periphery	Slo R.	B,L,F,D	20-50 m wide, moderate-rapid flow, nearby habitation, frequent use, ideal conditions for perennial breeding of <i>S. yahense</i>
6-Old Camp #1	12	S central	Chran Ba Ck.	B,L,F,D	5-10 m wide, moderate flow, clean, limited human use, good seasonal breeding potential, abundant aquatic vegetation
6-Old Camp #2	13	S central	Chran Ba Ck.	B,L,F,D	3-6 m wide, moderate flow, clean, nearby habitation, frequent use, seasonal breeding potential
Suati Camp #1	14	S periphery	Chran Ba Ck.	B,L,F,D	8-10 m wide, moderate flow, clean, nearby habitation, frequent use, seasonal breeding potential for <i>S. yahense</i>
Suati Camp #2	15	S periphery	Chran Ba Ck.	B,L,F,D	8-10 m wide, moderate-rapid flow, clean, nearby habitation, frequent use, potential breeding of <i>S. yahense</i>

Table 1 continued

LOCATION	MAP NO.	REF. LOCATION	WATERCOURSE	HUMAN USES	GENERAL DESCRIPTION
Steward Camp #1	16	S periphery	branch of New Cess R.	B,L,F,D	2-4 m wide, moderate flow, clean, nearby habitation, frequent use, seasonal breeding potential
Estate 2.2 office	17	S periphery	Gabu Ck.	B,L,F,D	2-6 m wide, moderate-rapid flow, clean, potential for perennial vector breeding
Estate 2 office	18	S periphery	branch of Chran Ba Ck	---	1-2 m wide, slow flow, weed-choked, poor vector breeding potential
Steward Camp #2	19	S periphery	branch of New Cess R.	---	1-2 m wide, slow flow, poor vector breeding potential
Estate 4 Camp	20	S periphery	Poinavo Ck.*	B,L	2 m wide, slow flow, limited use, poor breeding potential
6-New Camp #1	21	S central	Chran Ba Ck.	B,L,F,D	8-9 m wide, moderate-rapid flow, nearby habitation, frequent use, good seasonal breeding potential
6-New camp #2	22	S central	Chran Ba Ck.	B,F	7 m wide, slow flow, deep, poor breeding potential
Food Crop Camp #1	23	S periphery	Ho Bai Ck.	B,L,F,D	2-3 m wide, moderate flow, clean, limited seasonal breeding potential
Food Crop Camp #2	24	S periphery	Ho Bai Ck.	B,L,F,D	2-3 m wide, moderate flow, clean, limited seasonal breeding potential
Gissie Camp	25	central	Yani Ck.*	B,L	2-7 m wide, slow flow, frequent use, limited seasonal breeding potential
Bonaza Camp (Mohn)	26	central	Chran Ba Ck. (?)	B,L	2-7 m wide, slow seasonal flow, limited seasonal breeding potential
Small Cpd (Big-4)	27	central	branch of New Cess R.	B,L	2-8 m wide, slow flow, frequent use, limited seasonal breeding potential
Kongbwa Camp #1 (Dahn Camp)	28	central	branch of New Cess R.	B,L	2-8 m wide, slow flow, frequent use, limited seasonal breeding potential
Kongbwa Camp #2	29	central	branch of New Cess R.	B,L	2-8 m wide, slow flow, frequent use, limited seasonal breeding potential
3-Old Camp (Bosonbli Camp)	30	central	Yani Ck.*	B,L	1-4 m wide, slow flow, frequent use, limited seasonal breeding potential

Table 1 continued

LOCATION	MAP NO.	REF. LOCATION	WATERCOURSE	HUMAN USES	GENERAL DESCRIPTION
Huygen Camp	31	E periphery	Slo R.	B,L,F,D	12-14 m wide, moderate flow, frequent use, nearby perennial breeding conditions for <i>S. yahense</i> and <i>S. sanctipauli</i>
Old Teacher Camp	32	central	Klio Ck.	B,L,D	2-3 m wide, moderate-rapid flow, clean, potential for seasonal breeding
Waterfall	33	E periphery	Slo R.	B,L,F,D	15 m wide at top, 30 m wide rapids at bottom, fast flow, presumed ideal perennial breeding conditions for vector
Canoe crossing #2	34	NE periphery	Slo R.	F	30 m wide, slow flow, deep, limited use, poor vector breeding potential
Zia Camp	35	N central	Klio Ck.	B,L,F,D	2-3 m wide, moderate-rapid flow, clean, frequent use, nearby habitation, good potential for seasonal vector breeding
Dirt Hole Camp (old)	36	NE periphery	Suakbo Ck.*	B,L,F	3-8 m wide, slow flow, silty, frequent use, nearby habitation, limited seasonal breeding potential
Gorzhon Camp #3	37	central	Chran Ba Ck.	B,L	2-6 m wide, slow-moderate flow, nearby habitation, frequent use, limited seasonal breeding potential
Old Bean Camp	38	N periphery	(?)	B,L	1-2 m wide, slow flow, silty, frequent use, poor/limited seasonal breeding
Dirt Hole Camp (new)	39	NE periphery	(?)	B,F	2-3 m wide, slow flow, clean, limited use, poor vector breeding potential
Canoe crossing #3	40	NE periphery	Slo R.	F	30 m wide, slow flow, deep, limited use, ideal perennial breeding conditions 50 m downstream from site
Suati Camp #3	41	S periphery	Chran Ba Ck.	F	5-10 m wide, rapid flow, clean, ideal perennial breeding conditions, secluded
Sawmill Road	42	S periphery	Ho Bai Ck.	B,L,F,D	3-6 m wide, moderate-rapid flow, clean, limited perennial breeding potential
Sonveybli	43	S periphery	Yanmonmi Ck.*	B	1-2 m wide, slow flow, clean, limited use, poor vector breeding potential
Logging Rd. Bridge	N-1	N control	Slo R.	B,L,F,D	15 m wide, moderate flow, clean, limited use, good seasonal breeding potential
Sambli	N-2	N control	Suani Ck.*	B,L,D	2-3 m wide, moderate-rapid flow, clean, nearby habitation, frequent use, limited seasonal breeding potential

Table 1 continued

LOCATION	MAP NO.	REF. LOCATION	WATERCOURSE	HUMAN USES	GENERAL DESCRIPTION
Pega Publi	N-3	N control	Fuaye Ck.	B,F	2-3 m wide, slow flow, infrequent use, poor vector breeding potential
Canoe crossing #4	SW-1	W control	St. John R.	B,L,F	100 m wide, deep, moderate flow, limited use, seasonal breeding potential for <i>S. sanctipauli</i> / <i>S. soubrense</i>
Bubli	SW-2	W control	St. John R.	B,L,F	100 m wide, shallow, moderate-rapid flow, limited use, seasonal breeding potential for <i>S. sanctipauli</i> / <i>S. soubrense</i>
Kaya	SW-3	W control	St. John R.	F	50 m wide, extensive rapids, infrequent human use, ideal perennial breeding conditions for <i>S. sanctipauli</i> / <i>S. soubrense</i>
Koko David Town	SE-1	S control	Timbo R.	B,L,F,D	20-30 m wide, moderate-rapid flow, nearby habitation, frequent use, ideal conditions for perennial vector breeding
Josephbli	E-1	E control	Yoni Ck.	B,L,F,D	10-12 m wide, rapid flow, nearby habitation, frequent use, ideal conditions for perennial breeding of <i>S. yahense</i>

* Local name; undesignated on map

** B = Bathing; L = Laundering; F = Fishing; D = Drinking

Table 2. Recommended sites and sites of special interest surveyed for landing rates and human use. December 8 - 20, 1986.

LOCATION	MAP NO.	REF. LOCATION	NO. SAMPLE HRS.	MHI*	HUMAN INDEX**		
					men	women	children
15 Houses	4	NW periphery	13	0	1.5	2.8	5.8
<u>Raymond Camp</u>	6	NW periphery	24.3	3.3	1.7	1.8	2.1
Djueh Camp #1	9	central	7	0	---	---	---
Djueh Camp #2	10	central	14.8	0.3	0.5	0.9	1.4
Canoe crossing #1	11	W periphery	8.5	2.4	5.3	7.3	4.7
<u>6-Old Camp #1</u>	12	S central	22	2.9	1.5	1.3	1.0
6-Old Camp #2	13	S central	9	0.6	0.3	1.9	3.2
<u>Suati Camp #1</u>	15	S periphery	24	7.0	1.8	3.1	3.8
Steward Camp #1	16	S periphery	23.5	2.0	2.1	3.8	4.3
<u>6-New Camp #1</u>	21	S central	26	7.0	1.1	3.1	6.0
<u>Gissie Camp</u>	25	central	26	1.3	1.5	2.2	3.0
Bonaza Camp	26	central	8	0.3	1.0	1.3	9.0
Small Cpd (Big-4)	27	central	15.5	0.7	3.3	4.5	7.5
<u>Huygen Camp</u>	31	E periphery	27	2.7	1.3	0.6	1.5
Zia Camp	35	N central	8	0.1	1.5	2.5	6.3
Dirt Hole Camp (old)	36	NE periphery	8.5	0.1	6.6	5.4	6.9
Sawmill Road	42	SE periphery	7.5	0.4	3.6	3.3	2.1
PLANTATION TOTALS			272.6	2.0	1.9	2.4	3.7
<u>Logging Rd. Bridge</u>	N-1	N control	8	17.0	5.8	5.3	4.3
Sambli	N-2	N control	9.3	0	1.0	6.6	6.2
<u>Josephbli</u>	E-1	E control	8	4.5	1.1	1.5	3.4
<u>Koko David Town</u>	SE-1	S control	7.5	8.5	0.7	0.7	1.1
CONTROL TOTALS			32.8	7.8	2.1	3.7	3.9

* MHI (Man-Hour Index) = Mean No. Flies/Man/Hr.

** Human Index = Mean No. Humans/Hr. at site.

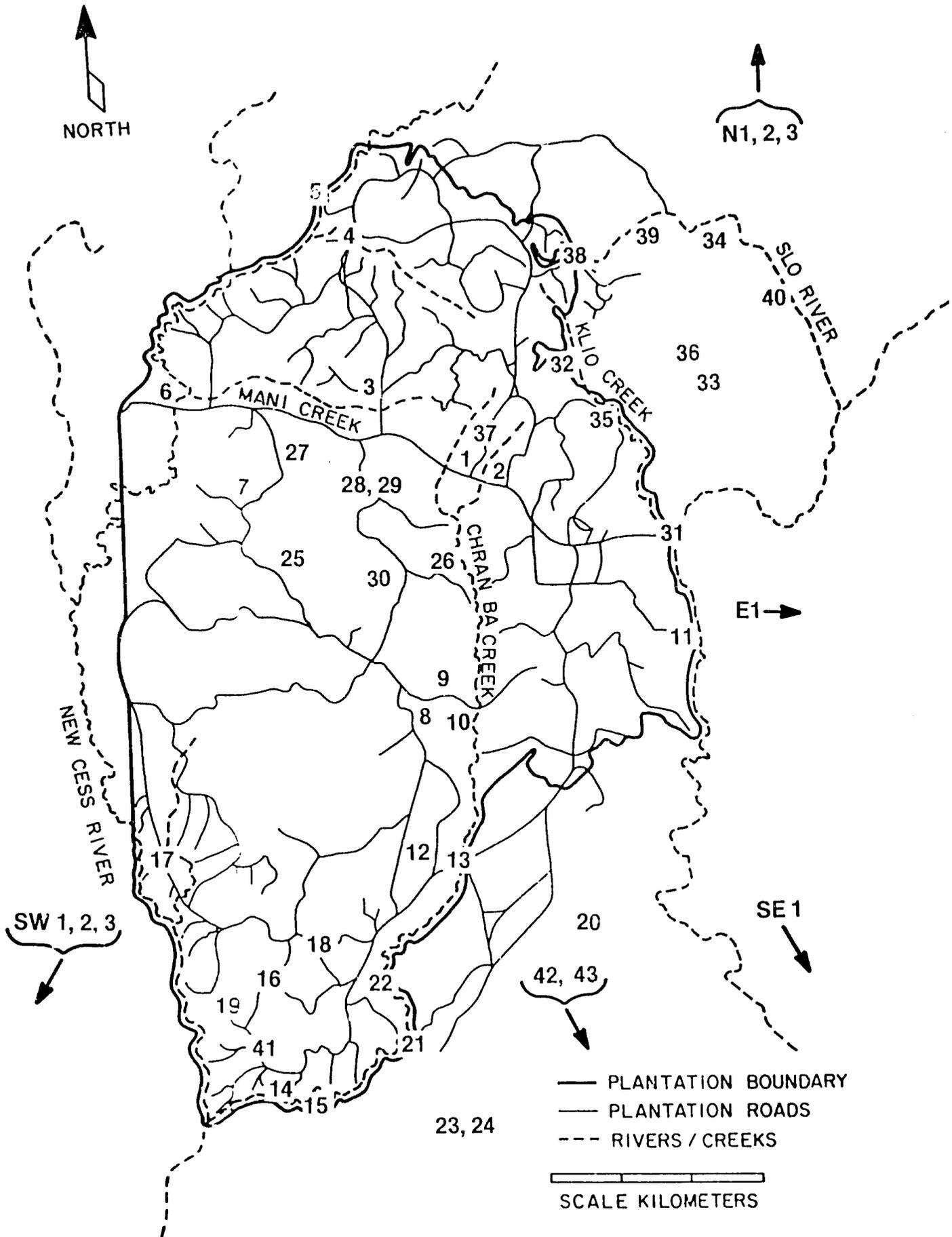
Table 3. Summary of entomologic and parasitologic results obtained from vector blackflies captured at URP-LAC and control regions. December 8 - 20, 1986.

LOCATION	MAP NO.	SPECIES	NO. DISSECTED	NO. PAROUS (%)	NO. INFECTED*	NO. INFECTIVE**
Raymond Camp	6	<i>S. yahense</i>	62	N.D.	16 (25.8%)	4 (6.5%)
Djueh Camp #2	10	<i>S. yahense</i>	6	5 (83.3%)	1 (16.7%)	0
Canoe crossing #1	11	<i>S. yahense</i>	20	19 (95%)	11 (55%)	2 (10%)
6-Old Camp #1	12	<i>S. yahense</i>	64	64 (100%)	34 (53.1%)	7 (10.9%)
Suati Camp #1	15	<i>S. yahense</i>	118	115 (97.5%)	58 (49.2%)	8 (6.8%)
Steward Camp #1	16	<i>S. yahense</i>	50	50 (100%)	22 (44%)	2 (4%)
Estate 2.2 office	17	<i>S. yahense</i>	2	1 (50%)	0	0
Estate 4 Camp	20	<i>S. yahense</i>	2	2 (100%)	1 (50%)	0
6-New Camp #1	21	<i>S. yahense</i>	162	162 (100%)	55 (34%)	11 (6.8%)
Gissie Camp	25	<i>S. yahense</i>	18	18 (100%)	3 (16.7%)	2 (11.1%)
Bonaza Camp	26	<i>S. yahense</i>	1	1 (100%) ³	0	0
Small Cpd (Big-4)	27	<i>S. yahense</i>	9	9 (100%)	4 (44.4%)	3 (33.3%)
Huygen Camp	31	<i>S. yahense</i>	60	57 (95%)	11 (18.3%)	3 (5%)
Zia Camp	35	<i>S. yahense</i>	1	1 (100%)	0	0
Dirt Hole Camp (old)	36	<i>S. yahense</i>	1	0	0	0
Sawmill Road	42	<i>S. yahense</i>	3	3 (100%)	1 (33.3%)	0
PLANTATION TOTALS			579	507 (88.1%)	217 (37.5%)	42 (7.3%)
Logging Rd. Bridge	N-1	<i>S. yahense</i>	146	142 (97.3%)	28 (19.2%)	7 (4.8%)
Canoe crossing #4	SW-1	<i>S. yahense</i>	1	1 (100%)	0	0
		<i>S. sanctipauli</i>	2	2 (100%)	0	0
Josephbli	E-1	<i>S. yahense</i>	55	53 (96.4%)	25 (45.5%)	8 (14.6%)
Koko David Town	SE-1	<i>S. yahense</i>	75	74 (98.7%)	18 (24%)	3 (4%)
CONTROL TOTALS			279	272 (97.5%)	71 (25.4%)	18 (6.4%)

* Based upon parasites indistinguishable from *Onchocerca volvulus*

** Based upon L3 stage *O. volvulus* only

Figure 1. Map of URP-LAC showing locations of sites examined for blackfly activity (Directions and numbers of control sites are indicated)



Rainfall Figures (mm) 1982

<u>Month:</u>	<u>2.1:</u>	<u>2.2:</u>	<u>2.3:</u>	<u>2.4:</u>
Jan.	-	-	-	-
Febr.	63.0	47.0	6.0	40.0
March	206.0	51.0	62.0	68.0
April	169.0	148.0	233.0	124.0
May	778.0	272.0	599.0	356.0
June	723.0	231.0	296.0	254.0
July	184.0	132.0	113.0	134.0
August	585.0	626.0	747.0	623.0
Sept.	326.0	336.0	387.0	382.0
October	347.0	351.0	296.0	345.0
November	108.0	89.0	167.0	156.0
December	33.0	11.0	2.0	2.0
<u>TOTAL:</u>	<u>3522.0</u>	<u>2294.0</u>	<u>2918.0</u>	<u>2484.0</u>

1983

Jan.	-	-	-	-
Febr.	55.0	78.0	36.0	84.0
March	109.0	103.0	101.0	67.0
April	97.0	85.0	85.0	201.0
May	331.0	272.0	324.0	430.0
June	351.0	306.0	356.0	478.0
July	127.0	136.0	84.0	168.0
August	299.0	270.0	188.0	370.0
Sept.	656.0	723.0	549.0	741.0
October	255.0	161.0	270.0	263.0
November	55.0	75.0	42.0	112.0
December	83.0	64.0	77.0	96.0
<u>TOTAL:</u>	<u>2420.0</u>	<u>2273.0</u>	<u>2112.0</u>	<u>3010.0</u>

1984

Jan.	5.0	1.0	48.0	14.0
Febr.	49.0	21.0	18.0	15.0
March	106.0	95.0	115.0	144.0
April	469.0	290.0	342.0	448.0
May	417.0	350.0	508.0	349.0
June	448.0	311.0	444.0	465.0
July	533.0	482.0	562.0	592.0
August	504.0	637.0	591.0	518.0
Sept.	398.0	264.0	359.0	334.0
October	352.0	325.0	396.0	294.0
November	313.0	170.0	225.0	187.0
December	38.0	20.0	26.0	24.0
<u>TOTAL:</u>	<u>3632.0</u>	<u>2966.0</u>	<u>3634.0</u>	<u>3384.0</u>

1985

Jan.	28.0	34.0	41.0	19.0
Febr.	70.0	42.0	73.0	51.0
March	37.0	62.0	42.0	97.0
April	63.0	64.0	160.0	135.0
May	380.0	424.0	389.0	339.0
June	328.0	315.0	354.0	410.0
July	431.0	333.0	430.0	494.0
August	973.0	860.0	887.0	933.0
Sept.	466.0	419.0	465.0	372.0
October	223.0	310.0	157.0	311.0
November	280.0	225.0	294.0	150.0
December	17.0	58.0	26.0	78.0
<u>TOTAL:</u>	<u>3296.0</u>	<u>3146.0</u>	<u>3318.0</u>	<u>3389.0</u>

1986

Jan.	-	-	-	-
Febr.	17.0	58.0	26.0	78.0
March	21.0	65.0	40.0	37.0
April	177.0	177.0	55.0	211.0
May	364.0	324.0	282.0	394.0
June	331.0	476.0	416.0	358.0
July	N/A	358.0	197.0	288.0
August	189.0	170.0	163.0	232.0
Sept.	467.0	523.0	521.0	576.0
October	198.0	316.0	278.0	286.0
November	139.0	115.0	82.0	94.0

Appendix 2

LIBERIAN AGRICULTURAL COMPANYLIST OF CAMPS WITH NAMES OF MANAGERS-IN-CHARGE

<u>DIVISION</u>	<u>CAMP</u>	<u># OF HOUSES</u>	<u>EMPLOYEES</u>	
			<u># OF ROOMS</u>	<u>MANAGER-IN-CHARGE</u>
1.1	Gbatua (Gboyah)	33	130	J. A. Bracewell
"	Bia-bia	25	100	"
"	Zienwhere	20	79	"
"	Ten Dollars	10	40	"
1.2	Operators'	25	100	"
"	Old Teachers'	18	70	"
"	Zea	23	92	"
"	Gorhzon New	16	64	"
"	Huygen's	6	24	"
1.3	Budding	21	82	"
"	Being	22	88	"
"	Johnson's	8	31	"
"	Quepuegar	14	56	"
"	St. Michael's	15	60	"
"	Div. 1.3 Office	3	12	"
1.4	Div. 8 (Manigoffa)	22	87	"
"	Main Gate (Raymond)	14	55	"
"	Big Four (Small Compound)	19	76	"
"	St. Michael's Old (Part)	10	44	"
"	5-Houses & 1.4 Office	7	28	"
"	Estate I Office	6	20	"
<u>ESTATE II</u>				
2.1	National Park	26	103	C. S. Ong
"	Kpein (Floyou)	12	47	"
"	Small 4 (Gonyou)	16	63	"
"	Gissie	10	44	"
"	Allamano's School	2	4	"
"	2.1 Office	1	4	"
2.2	7-Camp	28	111	"
"	Steward	8	32	"
"	Swatai	14	56	"
"	Djukolo (Old)	18	70	"
"	Djukolo (New)	4	16	"
"	2.2 Office	2	8	"
"	Estate II Office	2	4	"

Appendix 2

DIVISION	CAMP	# OF HOUSES	EMPLOYEES		
			# OF ROOMS		MANAGER-IN-CHARGE
2.3	2.3-Old(Basomablee)	30	119		"
"	Konboa (Dahn)	11	44		"
"	2.3 New(Mohn/Kanboniza)	11	44		"
"	Big 4 (Part 2.3)	5	20		"
"	2.3 Office	2	8		"
2.4	Djuehtown	42(1 Store)	165		"
"	6-Old	25	100		"
"	6-New (Mahzuoh)	17	66		"
"	2.4 Office	2	8		"
4.1	Estate IV	12	48		"
"	Food Crops	12	48		"
"	Junkpo (Native Huts)	5	17		"
<u>ESTATE III</u>					
3.1	CD (Part 3.1)	17	68		W. Kung
"	Dirt Hole (Old)	28	110		"
"	Dirt Hole New (Floo)	17	68 (Double)		"
"	Water Fall (Geezan)	10	40 (")		"
"	In'Velt (Fort Sherman)	10	40 (")		"
"	Being (Part 3.1)	7	28		"
<u>OTHERS</u>					
Admin.	Main Gorhzon	53(1 Store)	246 (190 Employees)		A. Morgan
"	Quinnsville	13	26 (26 ")		"
"	4-Houses	5	10 (5 ")		"
"	15-Houses	22	44 (22 ")		"
"	6-Houses	7	16 (8 ")		"
Medical	Nurses' Quarters	11	30 (18 ")		P. N. Williams
W/Shop	Vavoso's	40	160 (80 ")		G. M. Stanton/P.S. Nair
Transport	Drivers'	17	68 (34 ")		P. S. Nair
Factory	Toyota	22	88 (88 ")		"
"	Drying Bean	24	96 (90 ")		"
Maintenance	C. D. (Part Maint.)	7	16 (10 ")		W. S. Kamand

APPENDIX 4

Slides of URP-LAC and control areas

1. Mature rubber trees; typical biotype of URP-LAC Estate 1.
2. Newly planted rubber trees; URP-LAC Estate 3.
3. Secondary forest; URP-LAC Estate 4 and boundary region to south.
4. 6-New Camp #1; south central collection site, URP-LAC.
5. 6-New Camp #1; south central collection site, URP-LAC.
6. 6-Old Camp #1; south central collection site, URP-LAC.
7. 6-Old Camp #1; south central collection site, URP-LAC.
8. 6-Old Camp #2; south central, showing slash and burn with bathing/laundrying site.
9. Djueh Camp #2; central URP-LAC.
10. Klio Creek (Old Teacher Camp); central URP-LAC, showing small stream typical of central region.
11. Steward Camp; south central URP-LAC, showing small creek typical of central region.
12. Nodule of man's back; Suati Camp, south peripheral URP-LAC.
13. Suati Camp #1; south peripheral collection site, URP-LAC.
14. Canoe crossing #1; eastern peripheral collection site, URP-LAC.

15. Rapids at canoe crossing #1; eastern periphery, URP-LAC.
16. Raymond Camp; western peripheral collection site, URP-LAC.
17. 15 Houses; potential northern collection site, URP-LAC.
18. St. John River at Bubli; potential western control site for *S. sanctipauli*.
19. Logging road bridge at Slo River; northern control site.
20. Logging road bridge at Slo River; northern control site (view from bridge)
21. Suani Creek at Sambli; potential northern control site.
22. Josephbli on Joni Creek; eastern control site.
23. Koko David Town on Timbo River; southern control site.
24. Rapids above Koko David Town, a proven vector breeding site.

Appendix 6

GENERAL CHRONOLOGY

- Dec. 8 JEC and DJF departed JFK 2300 hrs. (EST) for Robertsfield, Liberia.
- Dec. 9 Arrived Liberia 1400 hrs., traveled to LIBR, obtained collection supplies and vehicle, arranged for field assistants and LIBR driver. Efforts made to contact A.I.D. mission in Monrovia by phone.
- Dec. 10 0700 hrs. Drove to URP-LAC, arriving at 1000 hrs. Met with Dr. P. N. Williams, K. D. Gerhart in a.m. Surveyed first eight sites p.m. Field assistants arrived 2130 hrs. from LIBR.
- Dec. 11 0700 - 1700 hrs. Assigned five field assistants to collection sites, continued survey of plantation.
- Dec. 12 0700 - 1730 hrs. Assigned four field assistants to collection sites. One assistant in lab for fly dissection. Continued plantation survey a.m.; northern control sites and Slo River control sites surveyed p.m.
- Dec. 13 0700 - 1730 hrs. Assigned four field assistants to collection sites. Three sites along St. John River surveyed for adult and larval blackflies. Drove to southern control site at Timbo River (Koko David Town) p.m.
- Dec. 14 (Sunday) 0700 - 1630 hrs. Assigned one field assistant to collection site; two assistants assigned to lab for dissections. Continued survey of URP sites.
- Dec. 15 0700 - 1630 hrs. Assigned four assistants and driver to collection sites, one assistant to lab for dissections. Vehicle refueling arranged through Mr. Henry Morgan, Bus. Mgr. Drove to Timbo River site and Ho Bai Creek. Estate 3 surveyed.
- Dec. 16 0700 - 1630 hrs. Assigned four assistants and driver to collection sites. DJF, JEC, and one assistant proceeded on foot to Yoni Creek (eastern control site). JEC personal acct. settled. Further survey of central and northern sites.

- Dec. 17 0700 - 0930 hrs. Returned from URP to LIBR. Assigned four assistants to collection sites, one assistant to lab for Dec. 17 and Dec. 18. 1130 hrs. Debriefed by Mr. S. Handleman and Mr. J. Cooper of USAID mission, Monrovia. USGS maps purchased, refueling arranged at LIBR. JEC returned to U.S.
- Dec. 18 0700 - 1200 hrs. Vehicle refueled, DJF returned from LIBR to LAC. Daily reports updated. Assistants pre-assigned duties.
- Dec. 19 0700 - 1830 hrs. Assigned five assistants to collection sites, VBC and personal acct. settled a.m. Larval survey of Chran Ba Creek by DJF and one assistant. Field assistants accts. settled p.m.
- Dec. 20 0700 - 0930 hrs. Assigned four assistants to collection sites, one assistant to lab. Settled acct. with URP drivers. Met with Mr. K. D. Gerhart, and Dr. P. N. Williams, 0930 - 1200 hrs. Returned to LIBR from LAC, 1300 - 1400 hrs. LIBR gasoline acct. settled; letter sent to Dr. A. P. Hanson. Vehicle and driver hired to pick up five assistants and equipment at URP and return same to LIBR, 2030 hrs. Assistants arrived from URP. Samples and data packed, 2300 hrs. DJF returned to U.S.