

PN AAP 650

15N-34077

9310971/62

PN-AAP-650

FINAL DRAFT REPORT

STUDIES ON ONCHOCERCIASIS IN NORTHERN LIBERIA,
INCLUDING TOPICAL TREATMENT WITH DIETHYLCARBAMAZINE:
PATHOLOGY, OPHTHALMOLOGY, PARASITOLOGY & ENTOMOLOGY;
AND RECOMMENDATIONS FOR CONTROL OF THE DISEASE

(26 November - 18 December 1978)

Report Prepared by: the Onchocerciasis Team for Liberia,

Daniel H. Connor, M.D., Pathologist (Team Leader)
Eddie W. Cupp, Ph.D., Entomologist
James P. Ganley, M.D., Dr.P.H., Ophthalmologist
Dean W. Gibson, Ph.D., Biophysicist
Everett L. Schiller, Ph.D., Parasitologist

Covering Studies
in Northern Liberia
during the Period:

26 November through 18 December 1978

Published by:

AMERICAN PUBLIC HEALTH ASSOCIATION

In agreement with:

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Authorized under

AID/ta-C-1320

STUDIES ON ONCHOCERCIASIS IN NORTHERN LIBERIA
INCLUDING TOPICAL TREATMENT WITH DIETHYLCARBAMAZINE:
PATHOLOGY, OPHTHALMOLOGY, PARASITOLOGY & ENTOMOLOGY;
AND RECOMMENDATIONS FOR CONTROL OF THE DISEASE

(26 November - 18 December 1978)

SUMMARY

A. Studies in Liberia: During 26 Nov through 18 Dec 1978, various aspects of the problems of onchocerciasis in Liberia were studied by a multi-disciplinary team of consultants to the American Public Health Association, in agreement with the U.S. Agency for International Development. The "Onchocerciasis Team for Liberia" included Dr. D.H. Connor, Pathologist (Team Leader); Dr. E.W. Cupp, Entomologist; Dr. J.P. Ganley, Ophthalmologist; Dr. D.W. Gibson, Biophysicist; and Dr. E.L. Schiller, Parasitologist. The team met with officials of the U.S. Embassy, USAID Mission, and the GOL Ministry of Health & Social Welfare; with the medical staffs of J.F.K. Hospital, T.N.I.M.A., the Liberian Institute of Biomedical Research, Firestone Medical Center, Phebe Hospital, Curran Lutheran Hospital/Forzor, Voinjama Hospital, Ganta United Methodist Hospital, LAMCO Hospital/Yekepa; and with onchocerciasis researchers at the Liberia Research Unit of the Tropical Institute Hamburg at Bong Iron Mine. The team also visited several Health Centers and Health Posts in upper Lofa County and Bong County: the Health Centers at Konia and at President Tolbert's Farm; the Health Post at Barkaimai; the Swedish Pentecostal Mission Clinic at Foya Kamara. The team visited ten breeding sites of black flies of the Simulium damnosum complex: 4 sites on the St. Paul River; and sites on Bene Creek at Konia, on Lawa River, on the Lofa River at Barkaimai, on the Baa River at Lugbeyee, on Yaa Creek near Zogowe, and on the St. John River near Baila. Experimental studies were conducted at Barkaimai, in upper Lofa County; at Lugbeyee, in upper Nimba County; and at Mawua near Bong Iron Mine. Patients were examined for clinical signs and symptoms of onchocerciasis; skin snips of the thighs were checked for microfilariae of Onchocerca volvulus; skin tests were performed with a microfilarial exoantigen; blood was drawn for immunochemical studies. Patients were treated with topical applications of diethylcarbamazine (DEC); with oral DEC ("Panocide"); with intradermal DEC; or with topical applications of thiobendazole ("Mintezol"). Xenodiagnostic assays were performed by catching black flies that had fed on legs topically treated with DEC, as well as on untreated legs. Visual acuities of the patients were measured, and complete ophthalmic examinations were performed with a slit lamp--to check for signs and symptoms of ocular onchocerciasis, as well as cataracts, glaucomas and other ocular lesions. The results of the experimental studies, as well as the team's conclusions and recommendations, were discussed in a final conference with officials of GOL/MOH, LIBR and the USAID Mission, plus onchocerciasis researchers at LRU-TIH.

B. Conclusions:

1. Onchocerciasis is a major public health problem in Liberia and adds to the "burden" of infectious disease carried by the people in endemic areas.
2. There are five major endemic areas: a) the valley of the St. Paul River; b) upper Lofa County; c) upper Nimba County; d) south-central Montserrado County (Firestone Plantations); and e) northern Grand Cape Mount County (along the Mano River)--as extensively studied by Frenzel-Beyme, 1975a, and coworkers at the LRU-TIH.

SUMMARY (continued)

B. Conclusions (continued):

3. Although forest and savannah types of onchocerciasis are not precisely defined nor easily distinguished--especially in individual patients--onchocerciasis in Liberia tends to be the forest type, because:
 - a. areas of endemicity are in bioclimatic zones that are generally forested;
 - b. transmission is intermittent and less intense than in the savannah;
 - c. the parasite appears to be vectored by Simulium sanctipauli, S. yahense and possibly S. damnosum (s.s.)--sibling species of the S. damnosum complex, each with different characteristic ecological settings;
 - d. eye complications in Liberia tend to be fewer and less severe than the savannah type in other countries, but comparable to the forest type elsewhere;
 - e. the densities of microfilariae in the skin (as determined by skin snips) tend to be lower than for the savannah type of onchocerciasis but comparable to the forest type in other countries.
4. The topical application of 2% DEC in Nivea Milk (introduced by Langham, Traub & Richardson, 1978) to the skin of patients with onchocerciasis produces a local cutaneous reaction characterized by pruritus, edema, and papules; and also produces swelling and tenderness in regional lymph nodes. Systemic effects may also be precipitated, as suggested by the appearance of generalized pruritus in some patients.
5. Histopathologic studies of 6-mm punch biopsy specimens of skin taken after one, two or three daily consecutive applications of topical DEC revealed a characteristic histopathologic pattern in "severe reactors" to the topical DEC. There was an intense cell infiltrate in neurovascular channels of the upper dermis, including large numbers of eosinophils and lymphocytes--and increased numbers of plasma cells in some cases. There were numerous foci of degenerating microfilariae in the upper dermis, within areas of necrosis. There were numerous intra-epidermal vesicles ranging in size between 1/20 and 2 mm across--corresponding to the papules seen clinically. These vesicles commonly contain fibrin, inflammatory mucin and fluid, in addition to eosinophils, neutrophils and desquamated epidermal cells. Segments of degenerating microfilariae are seen within the vesicles; and each smaller vesicle appears to be caused by a single microfilaria. The larger vesicles are commonly divided into compartments, and may result from confluence of smaller vesicles--and may therefore contain multiple degenerating microfilariae. The mechanism by which topical DEC produces this erythematous, papular reaction needs further study.
6. Xenodiagnostic assays revealed no substantial reduction in the numbers of microfilariae, nor loss of motor activity or loss of infectivity of the microfilariae--in the blood meal or thorax of black flies fed on limbs receiving 3 daily applications of topical DEC, in comparison with the microfilariae in black flies fed on the opposite, untreated limbs. This is contrary to what might be expected from the rapid reduction of microfilariae in skin snips after topical DEC, as reported by Langham et al, 1978.

SUMMARY (continued)

B. Conclusions (continued)

7. Xenodiagnosis was shown to be a reliable technique in the field for
a) diagnosing onchocerciasis; and b) evaluating the effects on microfilariae of topically and systemically administered DEC. Until pathogen-free black flies can be reared, however, this technique should not be generally used.
8. A skin test using microfilarial exoantigen (prepared from in vitro culture of O. volvulus microfilariae) produced a wheal measuring between 10-26 mm, in almost all patients with onchocercal nodules and other manifestations of onchocerciasis--even those with negative skin snips. This high degree of correlation with clinical manifestations indicates that this intradermal test is more sensitive than skin snips for diagnosing onchocerciasis.
9. Intradermal injection of DEC (25 mg in 0.25 ml saline) produced local erythema, induration, vesiculation and a mild generalized Mazzotti reaction--within 24 hours after injection. Some patients developed blisters at the site of injection.
10. Ophthalmic examinations using a slit lamp of 117 inhabitants of Barkaimai, Lugbeyee and Mawua revealed symptoms of ocular onchocerciasis in about 60% of them. There was punctate keratitis of the cornea in about 38%; microfilariae in the anterior chamber in about 41%; and chorioretinitis in about 21%--with the frequencies of the latter two symptoms increasing with age. In spite of these high frequencies of ocular onchocerciasis, the symptoms were minimal in most patients: only a few microfilariae in the cornea or anterior chamber; very few cases of proliferative chorioretinitis--but rather a diffuse depigmentation at about the pigment epithelial level; and the absence of a high frequency of optic neuritis and atrophy--in contrast to such severe symptoms in the savannah form of onchocerciasis. Nearly all patients with ocular onchocerciasis none-the-less had visual acuity in the normal range of 6/6 to 6/12; only about 10% of them had reduced acuity of 6/18 or worse. Other causes of reduced acuity included cataracts, glaucoma, trauma and measles. In summary, the eye is involved in the rain forest type of onchocerciasis but not to the same severity as in the savannah areas; and the risk of severe blindness is approximately 1% in the forest region, compared to 6-7% in certain endemic villages in savannah areas.
11. Primary health care in Liberia is delivered by physician's assistants (PA's) and midwives in a network of approximately 210 health clinics (Health Centers and Health Posts). In the absence of adequate numbers of PA's, additional midwives, aides and other non-professionals (dressers) staff the health clinics. There are physicians only in the few government, concession or mission hospitals in each county--many of which were visited by the team. This health care system is already overburdened; and the introduction of any new program of onchocerciasis control based in these health clinics would therefore probably require additional support, both personnel and material. Such a program in upper Lofa County could use the existing health clinics in the Lofa County Rural Health Project--supported by USAID; or the staff of the Schistosomiasis Control Program there might also be involved. A program in upper Nimba County might use workers at the YMCA clinics in many of the villages--with support from LAMCO hospital.

SUMMARY (continued)

C. Recommendations:

The Onchocerciasis Team for Liberia recommends that:

1. the GOL develop and execute a country-wide program to interrupt transmission and to alleviate the effects of onchocerciasis; and, to maximize its cost-effectiveness, this program should be integrated with the existing health care delivery system, with additional paramedical personnel; or possibly with other medical groups, such as the Schistosomiasis Control Program.
2. the program should be developed in collaboration with the World Health Organization and/or other international health agencies with expertise in the treatment, control and prevention of vector-borne diseases--perhaps as a model or pilot study to determine the efficiency of controlling the forest type of onchocerciasis. Support of the USAID, if any, should be through existing international health projects, such as the USAID Lofa County Rural Health Project.
3. as a first measure, GOL might adopt a regional pest management strategy to control black flies in areas where ocular onchocerciasis is determined to be a significant cause of blindness. The objectives of this strategy should be to reduce the intensity of infection by lowering the annual transmission rate of O. volvulus. Extant larviciding technology developed by the WHO Onchocerciasis Control Program (WHO/OCP) should be utilized where possible. Aerial spraying might be effective against breeding sites of Simulium sanctipauli and S. damnosum (s.s.) along wider, unshaded rivers such as the St. Paul and St. John Rivers; but aerial spraying is expected to be ineffective against breeding sites of S. yahense along narrow, shaded creeks and rivers. Ground spraying to control S. yahense would be a Herculean task, probably financially unfeasible.
4. in concert with No. 3 above, GOJ. should develop a clinical program to reduce the reservoir of O. volvulus adults and microfilariae in man, using one or more of the accepted chemotherapeutic measures, nodulectomy, and repellents.
5. that a limited and carefully controlled study of patients treated with topical DEC be done to determine the mechanism of action and efficacy; and that this study be planned and executed by a group of specialists including a clinician, pathologist, ophthalmologist, parasitologist, entomologist, epidemiologist and clinical pharmacologist. This study should be developed in cooperation with, or according to, the same protocols being used by the WHO/OCP, so that the results can be compared with the results of studies by WHO which, we understand, are now being undertaken in Ghana and Nigeria.

TABLE OF CONTENTS

	<u>page</u>
O. SUMMARY	i
I. INTRODUCTION	1
A. Team Composition	1
B. Objectives	2
C. Team's trip to Liberia	3
D. Review of earlier related studies in Liberia	4
1. Studies prior to 1970	4
2. Onchocerciasis studies at the LRU-TIH	4
3. Topical DEC studies on onchocerciasis patients at Firestone	5
4. APHA/USAID Reports	5
II. METHODS OF STUDY	7
A. Meetings in Washington, D.C. and Monrovia	7
B. Consultations at Liberian Institute of Biomedical Research	9
C. Consultations and Studies at the Liberia Research Unit of the Tropical Institute Hamburg	10
D. Consultations at Other Hospitals, Health Centers and Health Posts	11
E. Treatment with Topical and Oral DEC at Barkaimai	14
F. Treatment with Topical and Intradermal DEC, at Lugbeyee	15
G. Treatment Schedules	17
1. Topical DEC	17
2. Oral DEC	17
3. Intradermal DEC	17
4. Topical Mintezol	17
H. Pathology	18
1. Clinical Pathology	18
2. Biopsy Specimens	18
3. Histopathology--special stains	18
I. Ophthalmologic Examinations	19
1. Barkaimai	19
2. Lugbeyee	20
3. Mawua	20
J. Parasitology	21
1. Skin snips--microfilarial counts	21
2. Skin tests--sensitivity to microfilarial exoantigen	21
3. Blood specimens--immunochemical studies	22
K. Entomology	22
1. Ecological settings for sibling species of <u>S. damnosum</u>	22
2. Procedures for catching black flies	24
3. Xenodiagnostic assays	25
L. Photography	26
1. Scenic photographs	26
2. Clinical photographs	26
3. Photomicrographs	26
M. Conference of team with MOH, LIBR and USAID officials, in Monrovia	27
N. Preparation of Report	28
1. Preliminary Draft	28
2. Final Draft	28
3. Final Meeting of Team with APHA & USAID	28
4. Final Report	28

III. FINDINGS

- A. General Findings at Barkaimai 29
 - 1. Screening for signs and symptoms of onchocerciasis 29
 - 2. Demography--age and sex 29
 - 3. Skin snips and skin tests 30
- B. General Findings at Lugbeyee 31
 - 1. Screening for signs and symptoms of onchocerciasis 31
 - 2. Demography--age and sex 31
 - 3. Skin snips and skin tests 31
- C. Clinical Pathologic Findings at Barkaimai and Lugbeyee 32
 - 1. Pruritus, onchocercal dermatitis and gale filarienne 32
 - 2. Nodules 33
 - 3. Lymphadenopathy 34
- D. Reactions to Topical DEC 34
 - 1. Clinical findings 34
 - 2. Histopathologic findings 36
 - 3. Comparisons to reactions to oral DEC (Mazzotti Reaction) 38
- E. Reactions to Oral DEC 39
 - 1. Clinical findings 39
 - 2. Histopathologic findings 39
- F. Reactions to Intradermal DEC 40
 - 1. Clinical findings 40
 - 2. Histopathologic findings 40
- G. Reactions to Injection of Microfilarial Exoantigen 42
 - 1. Clinical findings 42
 - 2. Histopathologic findings 42
- H. Lack of Reaction to Topical Mintezol 43
 - 1. Clinical findings 43
 - 2. Histopathologic findings 43
- I. Ophthalmologic Findings 44
 - 1. Barkaimai 44
 - 2. Lugbeyee 45
 - 3. Barkaimai + Lugbeyee 47
 - 4. Mawua 48
- J. Parasitologic Findings 51
 - 1. Skin snips 51
 - 2. Skin tests 52
 - 3. Blood specimens 52
- K. Entomologic Findings 53
 - 1. Ecological settings for sibling species of S. damnosum 53
 - 2. Xenodiagnostic assays 54

- IV. DISCUSSION AND RECOMMENDATIONS--SUMMARY 55, i
 - A. Studies in Liberia i
 - B. Conclusions i
 - C. Recommendations iii

APPENDICES

- APPENDIX I. ITINERARY OF THE ONCHOCERCIASIS TEAM FOR LIBERIA 62
- APPENDIX II. CONTACTS IN LIBERIA 78
- APPENDIX III. BIBLIOGRAPHY ON ONCHOCERCIASIS IN LIBERIA AND NEARBY COUNTRIES; HISTOPATHOLOGY OF ONCHOCERCIASIS; OCULAR ONCHOCERCIASIS; ENTOMOLOGY OF SIMULIUM SPECIES; LOFA COUNTY RURAL HEALTH PROJECT; AND RELATED TOPICS 83

	<u>page</u>
<u>MAPS</u>	
MAP 1. Northern Liberia (Onchocerciasis Study)	90
MAP 2. Voinjama District, Upper Lofa County (Villages, Rivers, Clinics) ..	91
MAP 3. Locations Visited or Studied in Upper Nimba County	92
MAP 4. Black Fly Breeding Sites Visited in Northern Liberia (ecological settings of sibling species of the <u>S. damnosum</u> complex)	93
MAP 5. Locations Visited or Studied near Bong Iron Mine (Nov - Dec 78) ..	94

<u>TABLES</u>	
TABLE 1. Signs, Symptoms and Parasitological Parameters on Onchocerciasis Patients at Barkaimai Clinic, Lofa Co.	95
TABLE 2. Reactions to Treatment with Diethylcarbamazine or Mintezol for Onchocerciasis Patients at Barkaimai	96
TABLE 3. Signs, Symptoms and Parasitological Parameters on Onchocerciasis Patients at Lugbeyee, Nimba Co.	98
TABLE 4. Reactions to Treatment with Diethylcarbamazine for Onchocerciasis Patients at Lugbeyee	99
TABLE 5. Ophthalmologic Findings for Onchocerciasis Patients at Barkaimai	101
TABLE 6. Ophthalmologic Findings for Onchocerciasis Patients at Lugbeyee	104
TABLE 7. Frequencies of Ocular Onchocerciasis by Age Distribution, at Barkaimai, Lugbeyee and Mawua	108
TABLE 8. Comparisons of Age and Sex Distributions in Mawua, of Total Village and Patients given Eye Examinations	109
TABLE 9. Visual Acuity Levels by Age for Individual Eyes, among Inhabitants of Barkaimai, Lugbeyee and Mawua	110
TABLE 10. Causes of Visual Loss, among Inhabitants of Barkaimai, Lugbeyee and Mawua	111
TABLE 11. Visual Acuity of 6/18 or Worse by Cause of Decrease, among Inhabitants of Barkaimai, Lugbeyee and Mawua	112
TABLE 12. Comparisons of Microfilaria and Nodule Carriers in Mawua, of Total Village and Patients given Eye Examinations	114
TABLE 13. Xenodiagnostic Evaluations of Three Patients at Barkaimai after 1-3 Topical Applications of DEC	115

	<u>page</u>
<u>PHOTOGRAPHS OF ONCHOCERCIASIS TEAM AT WORK</u>	
FIGURE 1. Drs. Schiller and Cupp screening patients at Lugbeyee	116
FIGURE 2. Dr. Ganley giving ophthalmic examinations at Lugbeyee	117

CLINICAL PHOTOGRAPHS OF ONCHOCERCIASIS PATIENTS AFTER TREATMENT WITH DEC

FIGURE 3. Patient No. 12 (at Barkaimai), 22 hours after a single topical application of DEC--papular eruption of treated right thigh ...	118
FIGURE 4. Patient No. 12, 71 hours after the first of 3 consecutive daily topical applications of DEC--large vesicles in a more severe papular eruption of the treated right thigh only	119
FIGURE 5. Patient No. 13 (at Barkaimai), 24 hours after a single topical application of DEC-- <u>gale filarienne</u> of untreated left thigh ...	120
FIGURE 6. Patient No. 17 (at Barkaimai), 23 hours after a single topical application of DEC--papular eruption of treated right thigh ...	121
FIGURE 7. Patient No. 34 (at Lugbeyee), 23 hours after a single topical application of DEC--closeup of papules on treated thigh	122
FIGURE 8. Patient No. 35 (at Lugbeyee), 46 hours after a single topical application of DEC--excoriations of lower trunk and buttocks; sacral cluster of nodules showing the "Fuglsang sign"	123
FIGURE 9. Patient No. 59 (at Lugbeyee), 20 hours after treatment with intradermal DEC--closeup of blister at site of injection	124
FIGURE 11. Patient No. 63 (at Lugbeyee), 20 hours after treatment with intradermal DEC--closeup of vesicle at site of inoculation ...	126

GROSS PHOTOGRAPHS OF BIOPSY SPECIMENS FROM PATIENTS TREATED WITH DEC

FIGURE 10. Biopsy specimen 59A of blister from treated thigh of Patient No. 59, 20 hours after treatment with intradermal DEC (shown clinically in Fig. 9)	125
FIGURE 12. Biopsy specimen 12B of a large vesicle from treated right thigh of Patient No. 12, 71 hours after the first of three daily topical applications of DEC (shown clinically in Fig. 4)	127

PHOTOMICROGRAPHS OF BIOPSY SPECIMENS FROM PATIENTS TREATED WITH DEC

FIGURE 13. Intra-epidermal vesicle in biopsy specimen 12B (cf. Figs. 4 & 12), 71 hours after first of three daily topical applications of DEC; microfilaria and inflammatory cells within vesicle ..	128
--	-----

PHOTOMICROGRAPHS OF BIOPSY SPECIMENS FROM PATIENTS TREATED WITH DEC (cont.)

- FIGURE 14. Higher magnification of one portion of Fig. 13--showing cells and a microfilaria of O. volvulus within vesicle 130
- FIGURE 15. Another intra-epidermal vesicle in same biopsy specimen 12B from Patient No. 12, 71 hours after first of three daily topical applications of DEC (Fig. 12)--with degenerating microfilariae surrounded by inflammatory cells 130
- FIGURE 16. Intra-epidermal vesicle in biopsy specimen 31A from Patient No. 31 at 48 hours--after 2 daily topical applications of DEC--showing passage of a microfilaria into the abscess 131

PHOTOMICROGRAPH OF BIOPSY SPECIMEN FROM SKIN TEST WITH EXOANTIGEN

- FIGURE 17. Perivascular inflammation in biopsy specimen 19A, from Patient No. 19, 50 minutes after a skin test using a microfilarial antigen (from in vitro culture of O. volvulus microfilariae) 132

PHOTOGRAPHS OF ECOLOGICAL SETTINGS OF SIBLING SPECIES OF S. damnosum COMPLEX

- FIGURE 18. Black fly site #4 for Simulium sanctipauli: St. Paul River at bridge between Tolbert Farm, Bong Co. and Beyanstown, Lofa Co. 133
- FIGURE 19. Black fly site #9 for Simulium yahense: Yaa Creek near Zogowe, Nimba Co., south of the Nimba Range & LAMCO Iron Mine 133
- FIGURE 20. Black fly site #10 for Simulium damnosum (s.s.): St. John River at bridge between Nimba Co. and Baila, Bong Co. 134

I. INTRODUCTION

Following President Carter's visit to Liberia in March of 1978, President Tolbert of Liberia requested assistance from the United States for the control and eradication of onchocerciasis. The White House Health Affairs Staff requested a response to President Tolbert's request from the U.S. Agency for International Development (USAID). The USAID in turn entered into a contract with the American Public Health Association (APHA). The APHA assembled a consultants team of scientists to visit Liberia for three weeks during November to December 1978, to study the problem and to make recommendations regarding the control and eradication of onchocerciasis in Liberia. The team composition, objectives and trip are outlined in Sections I.A-C.

A. Team Composition

1. Daniel H. Connor, M.D., Pathologist (Team Leader),
Chairman, Department of Infectious and Parasitic Disease Pathology,
Armed Forces Institute of Pathology.
2. Eddie W. Cupp, Ph.D., Associate Professor of Entomology,
Department of Entomology, Cornell University.
3. James P. Ganley, M.D., Dr.P.H., Assistant Professor of Ophthalmology,
University of Arizona Health Sciences Center.
4. Dean W. Gibson, Ph.D., Research Biophysicist,
Department of Infectious and Parasitic Disease Pathology,
Armed Forces Institute of Pathology.
5. Everett L. Schiller, Ph.D., Professor of Parasitology,
Department of Pathobiology, Johns Hopkins University
School of Hygiene and Public Health.

These team members all had research experience with onchocerciasis in other African countries, but none had previously studied the disease in Liberia.

I. B. Objectives

The specific charges to the team were:

1. Review and assess all available data on the onchocerciasis problem in Liberia.
2. Discuss and review the problem with expert individuals in Liberia who have experience and knowledge of onchocerciasis.
3. Review and assess the national health plan, particularly as it relates to control of endemic diseases.
4. Review and assess the Government of Liberia's resources and capabilities for control of onchocerciasis and other tropical diseases.
5. Visit selected areas of Liberia, conduct examinations and carry out diagnostic studies to assess the magnitude of the health problems related to onchocerciasis.
6. Upon the basis of these studies, provide USAID with recommendations and/or analyses which will permit the Africa Bureau of USAID to determine what practical measures, if any may be undertaken to assist the Government of Liberia (GOL) in controlling onchocerciasis in a cost-effective and technically feasible manner. The recommendations and analyses should be developed in a fashion to allow USAID to provide any feasible assistance as a part of the rural health delivery system of GOL, rather than a separate (vertical) activity.

The fulfillment of these charges became the objectives of the team's studies in Liberia. Under charge 5, the team conducted independent studies of topical treatment with diethylcarbamazine, already being studied at the Firestone Plantations by Drs. Langham, Traub and coworkers (Section I.D).

I. C. Team's trip to Liberia

The team members were in Liberia for varying periods during 26 November through 18 December 1978. In Monrovia, the team had briefings with officials of the U.S. Embassy, the USAID Mission, and the Ministry of Health and Social Welfare/GOL, as well as with the staff of the John F. Kennedy Memorial Hospital. Elsewhere in Liberia, the team had briefings with medical directors and staffs of the Liberian Institute of Biomedical Research (LIBR), Firestone Medical Center, Elwa Hospital, Phebe Hospital/Suakoko, Curran Lutheran Hospital, Zorzor, Voinjama Hospital, LAMCO Hospital/Yekepa, Swedish Pentecostal Mission Clinic/Foya Kamara, and the Liberia Research Unit of the Tropical Institute Hamburg at the Bong Iron Mine (Map 1).

The team conducted experimental studies on the chemotherapy of onchocerciasis at the village of Barkaimai, in upper Lofa County (3-7 December); and at the village of Lugbeyee, in upper Nimba County (9-11 December). There were 23 patients at Barkaimai, and 34 patients at Lugbeyee, who received various treatments with topical diethylcarbamazine (DEC), oral DEC, intradermal DEC, topical Mintezol, or topical Nivea Milk control. Clinical pathologic features were observed before and after treatment: onchocercal dermatitis, nodules, and lymphadenitis. Microfilariae of Onchocerca volvulus were counted in skin snips of both thighs. Skin tests were performed to test the patient's sensitivity to an exoantigen derived from microfilariae in culture. Blood specimens were drawn for subsequent immunochemical studies at Johns Hopkins University. Punch biopsy specimens were taken for subsequent histopathologic studies at the Armed Forces Institute of Pathology (AFIP). Many of the patients were given ophthalmologic examinations with a slit lamp, to assess the manifestations of ocular onchocerciasis. A xenodiagnostic assay was performed, using black flies fed on topically treated legs. The

team also visited 10 breeding sites for black flies (Simulium species) at several rivers and creeks, and at some sites caught black flies. Dr. Ganley remained in Liberia through 18 December, and conducted another series of ophthalmic examinations, on 76 patients at the village of Mawua (Mauwa) in northern Montserrado County--in collaboration with the staff of LRU-TIH. Maps 1-5 show locations of the villages, rivers and black fly breeding sites.

A preliminary draft report was prepared during 11-14 December in Monrovia, and left with the USAID Mission for restricted distribution to GOL and LIBR. More detailed descriptions of all aspects of the trip to Liberia are given in Section II - Methods of Study; and in Appendix I - Itinerary of Onchocerciasis Team for Liberia. Appendices II & III list the team's Contacts in Liberia, and a Bibliography. (The preliminary draft report did not contain Dr. Ganley's subsequent results at Mawua, the histopathologic results, or the appendices.)

I. D. Review of Earlier Related Studies in Liberia (Appendix III)

1. Studies prior to 1970: Burch et al, 1955 give one of the earlier reports of onchocerciasis in Liberia. A long monograph by Gratama, 1966 compares Onchocerca volvulus and Wuchereria bancrofti in southeastern Liberia--in relation to the pathogenesis of elephantiasis and hydrocele.
2. Onchocerciasis studies at the Liberia Research Unit of the Tropical Institute Hamburg (LRU-TIH): Extensive studies of onchocerciasis and its vectors in Liberia have been carried out by the staff of the LRU-TIH, at the Bong Iron Mine. The prevalence and geographic distribution of onchocerciasis in Liberia are reported by Frentzel-Beyme, 1973 & 1975a. Reports on the black fly vectors (Simulium species) --in different rivers, creeks and are bioclimatic zones of Liberia--/given by Garms & Post, 1967; Garms, 1972a,b, 1973a,b,c & 1974; Garms & Vajime, 1975; and Vajime & Dunbar, 1975. The Annual

Reports of the LRU-TIH for 1977 and 1978 describe subsequent studies that found O. volvulus and W. bancrofti in villages around Foya Kamara, in the more westerly portion of upper Lofa Co. (Map 1); whereas only O. volvulus was found between Voinjama and Zorzor, in the more easterly portion of upper Lofa Co.--where Barkaimai is located.

I. D. 3. Topical DEC Studies--on Onchocerciasis Patients at Firestone Plantations:

Oral DEC is the classical treatment to kill microfilariae of O. volvulus (reviewed by Gibson et al, 1976). Recently there have been clinical trials of topical treatment with 2% DEC in a Nivea Milk base, carried out at the Firestone Plantations by Dr. M. F. Langham (Johns Hopkins University); Dr. Z. D. Traub (Fire^{stone} Medical Center) and coworkers. Preliminary results have been published by Langham et al, 1978; and more controlled clinical trials are underway there during February - March 1979. Dr. Langham gave samples of the 2% DEC in Nivea Milk to Dr. Schiller (in a different department at Johns Hopkins University). The team used these samples for independent studies at the villages of Barkaimai and Lugbeyee (Sections II.E & F; III.A & B).

4. APHA/USAID Reports: The team reviewed two recent reports by APHA, under contract to USAID, to assess the national health plan and especially the rural health delivery system of GOL (charges 3, 4 & 6 in Section I.B). These two APHA/USAID Reports are:

- a. Lofa County Rural Health Project--Liberia, West Africa (1975); and
- b. Environmental Health Assessment--Liberia (1977).

Some data on onchocerciasis in Liberia is given in (b), but there is none in (a). Report (a) was especially helpful in explaining the hierarchy of Hospitals, Health Centers, and Health Posts--within the rural health

system of Lofa County. The team's main contact at Voinjama was Dr. George Berg, Chief of Party of the Lofa County Rural Health Project, USAID/Voinjama. In order to understand the rural health project better, the team also visited several hospitals, health centers and health posts. This included five days at the Barkaimai Health Post studying topical and oral treatments with DEC (Sections II.E and III.A).

II. METHODS OF STUDY

A. Meetings in Washington, D.C. and Monrovia

1. USAID/APHA Briefing, Washington, D.C.: The team met on 20 November 1978 at the Africa Bureau, USAID. They were briefed on the charges to the team and the logistics of the trip to Liberia, by Drs. Stockert, Buck, George and Cross of USAID; and by Dr. Dalmat of APHA. Arrangements for passports and visas were also facilitated by the USAID and APHA staffs.
2. Briefings and Orientation, Monrovia: Drs. Connor, Gibson and Schiller arrived in Monrovia 27 November; Dr. Cupp arrived 29 November; and Dr. Canley arrived 5 December. During 27 November through 1 December and on 3 December the respective team members met with members of the USAID Mission/Monrovia, with officials of the U.S. Embassy, the Liberian Ministry of Health and Social Welfare; and with staff members of the John F. Kennedy Hospital and the Tubman National Institute of Medical Arts. Topics of discussion included the national health plan, the rural health delivery system of GOL, problems of onchocerciasis in Liberia, and the logistics of the team's proposed field studies in Bong, Lofa and Nimba Counties--with a view towards fulfillment of the objectives outlined in Section I.B above. Some of the important briefings are summarized in the following subsections, but are discussed in more detail in Appendix I - Itinerary of Onchocerciasis Team for Liberia. The full titles of the officials, medical officers and hospital or clinic staffs are given in Appendix II - Contacts in Liberia.
 - a. USAID Mission/Monrovia: The team had numerous briefings with Deputy Director, Edward Anderson and members of the USAID staff: Mr. Marsh, Mr. Hagel, Mr. Cornelius, Mr. Tennyson, Dr. Mertens, Mr. Correa, Ms. Kpabar and others. Our USAID drivers were Mr. Khan and Mr. Attia.

- II. A. 2. b. U.S. Embassy/Monrovia: The Deputy Chief of Mission, Julius Walker, met 27 November with Drs. Connor, Gibson and Schiller and Deputy Director Anderson of USAID/Monrovia. The Embassy physician, Dr. Theodore Lefton, met 18 December with Dr. Ganley and discussed the team's preliminary findings.
- c. Ministry of Health and Social Welfare (MOH): The Minister of Health and Social Welfare, Kate Bryant, and Deputy Minister Ellis met 27 November with Drs. Connor, Gibson and Schiller. Several officials of MOH also attended the team's final conference at MOH on 13 December (Section II.M).
- d. John F. Kennedy Memorial Hospital: On 28 November, Drs. Connor and Gibson met with the Chief of Pathology, Dr. Brewer and the Chief of the Ophthalmology Clinic, Dr. Tudae-Torbah. On 13 December, Dr. Ganley also visited the Ophthalmology Clinic and met with Dr. Tudae-Torbah and his colleague Dr. Han. They discussed causes of blindness in general and the occurrence of onchocerciasis in their clinic. On 12 December, Drs. Connor and Ganley met the Chief of Medical Services, Dr. Nehemiah Cooper, and discussed the team's findings at Barkaimai and Lugbeyee, as well as the team's recommendations for further treatment and control of onchocerciasis. On 14 December, Dr. Ganley made in-patient ward rounds and saw a few patients in the out-patient clinic--thus gaining first-hand view of selected eye conditions in a hospital setting. He also talked to Dr. van Reken, staff pediatrician, and discussed measles keratitis in some detail.

II. A. 2. e. Tubman National Institute of Medical Arts (TNIMA): Drs. Connor and Gibson met 30 November with Dr. Paul Mertens, USAID Instructor of physician's assistants and midwives at the TNIMA. He discussed the training of PA's and midwives for the Health Centers and Health Posts throughout Liberia, in general; and the Lofa County Rural Health Project in particular. Dr. Mertens had extensive prior experience in upper Lofa County--as medical director of Curran Lutheran Hospital/Zorzor; and on the USAID staff at Voinjama in charge of the rural health project. Dr. Mertens gave us copies of the October 1974 Proposal for the "Lofa County Rural Health Project" and the May 1978 "Status Summary of the Lofa County Rural Health Project". These were very helpful regarding objectives 3, 4 and 6 in Section I.B. Dr. Mertens also expedited the arrangements for the team's studies up-country--through MOH radio contacts with Phebe Hospital/Suakoko and Voinjama Hospital.

B. Consultations at the Liberian Institute of Biomedical Research (LIBR):

The LIBR is located about 30 miles east of Monrovia, and a few miles south of Roberts International Airport near Harbel (Map 1). On 30 November, team members consulted for about 90 minutes with Dr. Emmet Dennis, Director of LIBR--who served as professional consultant to the team. We discussed our proposed studies in Bong, Lofa and Nimba Counties, including treatment with topical DEC (Section I.D.3). After completing our studies up-country, the team returned 12 December for the dedication of LIBR, and used that opportunity to discuss our findings at the villages of Barkaimai and Lugbeyee (Sections II.D-K and III.A-K). Dr. Dennis also participated in the conference on 13 December at MOH in Monrovia (Section II.M).

II. C. Consultations and Studies at the Liberia Research Unit of the Tropical Institute Hamburg (LRU-TIH):

The LRU-TIH is located at the Bong Iron Mine, about 50 miles northeast of Monrovia (Maps 1 & 5). Since 29 November was a Liberian holiday (former President Tubman's birthday), the USAID and MOH offices were closed; so Drs. Connor, Gibson and Schiller used that day for a trip to LRU-TIH-- the place where so much of the research on onchocerciasis in Liberia has been centered.

We consulted there with Drs. Dietrich Blüttner and Eberhard-Johannes Albiez, staff members of LRU-TIH currently studying onchocerciasis. They discussed their current studies of adult O. volvulus "purified" by digesting nodules with collagenase. Dr. Blüttner also reviewed the earlier work at LRU-TIH on the geographic distribution of onchocerciasis in Liberia, and breeding sites of the black fly vectors (discussed in Section I.D.2 above). The team was given copies of the LRU-TIH Annual Reports for 1976 and 1977, which described unpublished results on distributions of O. volvulus and W. bancrofti in several regions of Liberia.

Dr. Blüttner took us to the nearby hyper/^{endemic} village of Hendi (studied by Frentzel-Beyme, 1973), and to three breeding sites for Simulium species on the St. Paul River near Hendi (described by Garms, 1973h)--all of which are shown on Map 5. Dr. Blüttner also cited breeding sites elsewhere in Bong, Lofa and Nimba Counties (described by Garms & Vajime, 1975)--sites that the team subsequently visited enroute to Barkaimai and Lugbeyee (Map 4, and Section III.K). The consultations of the team at LRU and site visits near Hendi lasted about seven hours. During 14-18 December, Dr. Ganley was based at LRU-TIH, for collaborative studies at the village of Mawua (Map 5, and Section II.I.3). Those studies involved Drs. John Ehrenberg and Mathias Stierle in addition to Drs. Blüttner and Albiez.

II. D. Consultations at Other Hospitals, Health Centers and Health Posts

1. Firestone Medical Center/Harbel: On 28 November, Drs. Connor and Gibson consulted for about an hour with Dr. Zolu-Dumah Traub, Ophthalmologist at the Firestone Medical Center. Discussions included Dr. Traub's collaboration with Dr. Langham on treatment with topical DEC (Section I.D.3). In particular, Dr. Langham had given Dr. Schiller samples of the 2% DEC in Nivea Milk; and the team proposed to study its effects on selected patients. The team also discussed ophthalmological studies to be performed by Dr. Ganley upon his arrival--possibly in collaboration with Dr. Traub. Dr. Traub offered to loan Dr. Ganley a slit lamp and portable generator; but cables about this didn't reach Dr. Ganley--who instead used a slit lamp and small generator brought from the U.S.A. Following Dr. Ganley's ophthalmologic studies at Mawua (Section II.I.3), he met Dr. Traub at Firestone Medical Center on 18 December, and discussed Dr. Traub's ophthalmologic findings after topical DEC treatment (Section I.D.3). Dr. Traub also discussed causes of blindness, ocular conditions, and onchocerciasis seen in his clinic.

2. Phebe Hospital/Suakoko: Phebe Hospital is located at Suakoko, about 120 miles northeast of Monrovia, and near Gbarnga, capital of Bong County (Map 1). On 1 December, the team stopped overnight and consulted for about two hours with Dr. Walter Gwenigale, Medical Director, and Dr. A. F. David. We discussed the possibility of using Phebe Hospital as a base for studying hyperendemic villages such as Beyanstown and Gblatuah (villages #20 and #72, in Frentzel-Beyme, 1975a). These villages, however, were not finally chosen--since Voinjama was chosen for a base instead (Sections II.D.4 and II.E).

- II. D. 3. Curran Lutheran Hospital/Zorzor: On 2 December, while enroute to Voinjama, the team consulted for about an hour at Zorzor (Map 1) with Dr. Erik Svenkerud, Medical Director of the Curran Lutheran Hospital--discussing onchocerciasis and other diseases in the Zorzor District. In particular, he discussed the ulcer of a former patient who we subsequently examined and biopsied at Foya Kamara (Section II.D.5).
4. Voinjama Hospital and Barkaimai Health Post: During 2 through 7 December, the team was based at the USAID guest house in Voinjama, capital of Lofa County--located about 250 miles by road from Monrovia (Maps 1 & 2). While there we consulted on several occasions with the staff of Voinjama Hospital and Lofa County medical officials, including Drs. George Berg, Ivan Camanor, and N. Ramamoorthy. Based on these discussions, the team carried out experimental studies at the Health Post in the village of Barkaimai (known locally as Barkeidu)--about 18 miles by road from Voinjama (Map 2; Section II.E).
5. Swedish Pentecostal Mission Clinic/Foya Kamara: On 6 December, Drs. Connor and Gibson consulted with the head nurse, Ms. Irene Stahlberg, and other staff of the Swedish Pentecostal Mission Clinic at Foya Kamara--about 40 miles by road west of Voinjama (Map 2). We discussed onchocerciasis and bancroftian filariasis in that area; and Drs. Connor and Gibson took biopsy specimens from two young boys at the clinic (one being the former patient of Dr. Svenkerud--Section II.D.3). These patients had large necrotizing cutaneous ulcers of the knee (patient No. 25; AFIP Accession No. 1679433) and of the foot (patient No. 26; AFIP Accession No. 1679432). Subsequent microscopic studies at the AFIP revealed fat necrosis and acid-fast organisms (Mycobacterium ulcerans) in both biopsy specimens, enabling diagnoses of Buruli ulcer--the first two in Liberia. These boys are now back at Curran Lutheran Hospital, under treatment by Dr. Svenkerud.

II. D. 6. Health Centers at President Tolbert's Farm/Gblatuah and at Konia:

On 4 December, while enroute from Phebe Hospital to Voinjama, Dr. Gibson visited the Health Centers at President Tolbert's Farm near Gblatuah, and at Konia--talking about onchocerciasis with the respective physician's assistants: Capt. Joseph L. Johnson, Medical Officer, MSC; and Daniel Dalton, P.A.; plus midwives and technicians at both health centers.

On 8 December, while enroute from Voinjama to Yekepa, the entire team stopped for visits at these two Health Centers.

7. Ganta United Methodist Hospital: On 8 December, while enroute to Yekepa, the team consulted with Dr. Ring Decima, G.P. at Ganta United Methodist Hospital--in the absence of Dr. Walter Stephenson, Chief Medical Officer.
8. LAMCO Hospital/Yekepa: During 8 through 11 December, the team was based at the LAMCO Guest House, at the LAMCO Iron Mine near Yekepa--located about 215 miles by road northeast of Monrovia, very close to the border with Guinea and Ivory Cost (Maps 1 & 3). The team had numerous consultations with the staff of LAMCO Hospital/Yeke^{pa} and the related research unit affiliated also with LIBR: Dr. Warsay Sirleaf, Chief Medical Officer; Dr. Anders Björkman, Research Officer; and Dr. Michael Wilcox, Research Officer. These doctors were consulted on many aspects of our studies, but in particular about topical DEC treatment at the nearby village of Lugbeyee--about 8 miles by road from Yekepa (Map 3; Section II.F).
- Drs. Björkman and Wilcox also accompanied Drs. Cupp and Schiller to the black fly site^{#9}/on Yaa Creek, about 20 miles south of Yekepa (Map 4; Section II.K). Drs. Connor and Gibson met twice with Orwar Alnesiø, Executive Director of the regional YMCA at Yekepa--which runs the maternal and child health clinic at Lugbeyee. The team used the YMCA clinic pavilion there for part of our onchocerciasis studies (Fig. 1; Section II.F).

II. E. Treatment with Topical and Oral DEC at Barkaimai

After discussions with Drs. Berg, Camanor and Ramamoorthy (Section II.D.4), the team selected the village of Barkaimai for extended studies of treatment with topical DEC. Barkaimai was village #7 of Frentzel-Beyme, 1975a who reported that 44% of the villagers had positive skin snips for microfilariae of O. volvulus (72% of those above 30); and 29% had onchocercal nodules. This village of about 900 inhabitants is on a side road, about 8 miles east of the road from Zorzor to Voinjama and 8 miles west of the Guinea border (Map 2). Barkaimai is a few hundred yards from the Lofa River, where the villagers wash clothes, fetch water, swim, and cross the river on a raft to harvest crops; and where there are many black flies (Map 4, Site #7).

Dr. Camanor accompanied the team to Barkaimai 3 December and introduced us to officials of the village. The consent was obtained from the outgoing chief, Lansana Kanneh; and from the new chief as well, Mabulu Dulleh, who was one of the patients in the study. The trained midwife, Mary Yallah, helped the team set up examination rooms in the Barkaimai Health Post-- a few hundred yards west of the village. The team was assisted in screening and treating patients, and with translations, by the staff of the Health Post: James Nah, P.A.; Mary Yallah, trained midwife; Mamadee Dolleh, Aide; and occasionally by two empirical midwives. Over 60 adults from Barkaimai were screened for onchocercal nodules, dermatitis, lymphadenitis, and other overt manifestations. We selected 22 onchocerciasis patients for more detailed study: patients No. 1 - 17 and 19-23 in Table 1. In addition, a skin test was done and blood drawn on Dr. Camanor (patient No. 24). A biopsy specimen was also taken of a penile lesion of patient No. 18 (AFIP Accession No. 1679373), who showed no signs of onchocerciasis; subsequent histopathologic studies at AFIP enabled a diagnosis of a well-differentiated squamous cell carcinoma-- now being treated surgically at Voinjama Hospital by Dr. Camanor.

The onchocerciasis patients at Barkaimai were tested by several diagnostic procedures: skin snips (Section II.J.1); skin tests using exoantigens prepared from cultivated microfilariae (II.J.2); blood specimens for immunochemical studies (II.J.3); and punch biopsy specimens for histopathology (II.H.2,3). The patients were treated for up to three days with topical DEC, oral DEC, topical thiobendazole (Mintezol) or topical Nivea Milk control-- as given in Table 2. and Section II.G below. The patients were followed for up to three days after the initial treatment. A few patients with positive skin snips were chosen for xenodiagnosis--where black flies were caught after feeding on the treated or untreated leg (Section II.K.3). Dr. Ganley arrived in time for eye examinations on 7 December--1 to 3 days after the initial treatments for most patients (Table 5). The treatment schedules, pathologic, ophthalmologic, parasitologic and entomologic studies on these patients are outlined in Sections II.G-K.

II. F. Treatment with Topical and Intradermal DEC, at Lugbeyee:

After discussions with Drs. Sirleaf, Björkman and Wilcox at LAMCO Hospital (Section II.D.8), the team arranged for studies at the village of Lugbeyee (Lugbeh). This village of about 750 inhabitants is located about 8 miles by road northwest of Yekepa and 4-6 miles in three directions from the Guinea border (Map 3). Lugbeyee is village #101 of Frentzel-Beyme, 1975a-- who reported that 81% of the villagers had positive skin snips for microfilariae of O. volvulus (more than 90% of those above age 30); and 57% had onchocercal nodules. Dr. Björkman assisted in getting the consent of the Chief, Quoi Duo; and patients in the study included a Quarter Chief, Stephen Belleh. We were assisted by a translator, Peter Komak, aide at LAMCO Hospital; and by two translators from the village: James Paye, and James Lakpor.

Initial screening on 9 December was carried out at the YMCA clinic pavilion in Luginbeye, except that ophthalmologic studies were done in the school master's house next to the pavilion (Figs. 1 & 2). Our studies were shifted to the Luginbeye Public School for 10 and 11 December, at the suggestion of the Chief. On 9 December, about 25 villagers were screened and 15 who had onchocercal nodules and/or dermatitis were selected for treatment with topical DEC: patients No. 31-45 in Tables 3 & 4. On 10 December, more villagers were screened and an additional 19 patients were selected, most of whom were given an intradermal injection of DEC: patients 46-48 and 50-65 in Tables 3 & 4. (There is no patient No. 49, because the villager assigned No. 49 had previously been assigned No. 44.) Patients No. 31-45 only were tested by skin snips (Section II.J.1); skin tests (II.J.2); and blood specimens (II.J.3). Selected patients from both groups (receiving topical or intradermal DEC) were biopsied for histopathology (Table 4; Section II.H.2,3). The patients were treated for up to two days with topical or intradermal DEC. Most of the patients No. 31-65 were given ophthalmologic examinations (Table 6; Section II.I.2). Dr. Ganley also examined the eyes of 9 villagers (No. 66-74) who had reduced visual acuities but were not studied by the rest of the team (Table 6).

II. G. Treatment Schedules

1. Topical DEC: 2% DEC in Nivea Milk was obtained from Dr. Langham, Johns Hopkins University (Langham et al, 1978; see Section I.D.3 above). This lotion was applied to the entire right leg, from the inguinal region to the top of the sole of the foot. The untreated left leg served as control. Such treatment with topical DEC was given to 10 patients at Barkaimai, and to 16 patients at Lugbeyee (Tables 2 & 4). In general the topical treatment was repeated on consecutive days, for up to three treatments at Barkaimai and two treatments at Lugbeyee. Of the patients at Lugbeyee, however, patient No. 40 applied the lotion to both legs; patients No. 33, 44 & 65 didn't return for followup; and patients No. 38, 39, 40, 42 & 43 returned once at 22-23 hr for followup examination and a second topical treatment, but didn't return the next day for further followup. As a control, Nivea Milk containing no DEC was applied to the right leg of patients No. 2 and 21. In Mawua, Dr. Ganley applied the 2% DEC in Nivea Milk to the faces of four patients, on two consecutive days, and examined their eyes on the third day (Section II.I.3).
2. Oral DEC: oral doses of 100 mg DEC ("Banocide") were given--a single dose to patients No. 16 and 21; and two daily doses to patient No. 23. This served as a Mazzotti Test for microfilariae of O. volvulus.
3. Intradermal DEC: A single intradermal injection of 0.25 ml of saline containing 25 mg DEC was given in the left anterior mid-thigh of 16 patients at Lugbeyee, except that the right thigh was used for patient No. 59 (Table 4). Patients No. 53 and 64 didn't return for followup.
4. Topical Mintezol: Thiobendazol liquid ("Mintezol") was rubbed on the right leg of patients No. 2, 8, 11 and 20 at Barkaimai (Table 2). Thiobendazol is a promising and now widely used anti-nematodal drug that has recently been used topically to treat cutaneous larval migrans (Guill et al, 1978).

II. H. Pathology (Drs. Connor and Gibson)

1. Clinical Pathology: The patients at Barkaimai and Lugbeyee were screened for signs and symptoms of onchocercal dermatitis and lymphadenitis: the presence of onchocercal nodules; pruritus, wrinkling, scaling, atrophy, depigmentation, gale filarienne, and/or maculo-papular eruptions of the skin; and fullness of the inguinal or femoral lymph nodes. These features are described in more detail by Connor et al, 1970; Gibson et al, 1976; and Gibson and Connor, 1978, .
2. Biopsy Specimens: A local anesthetic was injected, and the skin tested for anesthesia. Biopsy specimens of skin were taken with 6-mm punches (or a 4-mm punch, from the outer canthus of patient No. 16), to full thickness of skin and into the subcutaneous fat (Connor et al, 1970). Such "true" biopsies are distinguished from the shallow skin snips which should include only the superficial dermis--ideally no more than the dermal papillae--such as the skin snips called "biopsies" by Langham et al, 1978. Our full-thickness skin biopsies were generally taken one to three days after treatment with topical DEC, intradermal DEC, oral DEC, or topical Mintezol; or 25-50 minutes after skin tests for patients No. 15 and 19 (Tables 2 & 4). The shallow skin snips taken before treatment, and counted for microfilariae of O. volvulus, were subsequently fixed in formalin for paraffin sections and microscopic study.
3. Histopathology--special stains: Biopsy specimens were fixed in formalin, embedded in paraffin, and cut at 6 microns. Slides were stained with hematoxylin and eosin (H & E), with the Russell-Movat stain to differentiate connective tissue elements, or with the Giemsa stain--as described by Connor et al, 1970 and Russell, 1972.

II. I. Ophthalmic Examinations (Dr. Ganley)

Ophthalmic examinations consisted of visual acuity determination, slit lamp biomicroscopy of the anterior segment, and dilated funduscopy. The visual acuity examination was conducted out of doors in the bright sunlight. The "tumbling E" method was used at 6-meter distance, marked off at 1-meter intervals. A cube contained the following sized "E's": 6/6, 6/9, 6/12, 6/18, 6/24, and 6/36; and a 6/60 "E" was also available at Mawua. At distances closer than 6 meters, the 6/36 "E" was used at Barkaimai and Lugbeyee, and the 6/60 "E" was used at Mawua. Each eye was tested separately. Uncorrected vision was recorded. The Zeiss slit lamp was used for biomicroscopy. The cornea was examined at 16X magnification for microfilariae, punctate opacities, perilimbal and nasal-temporal infiltrates, and sclerosing keratitis. The anterior chamber was evaluated for keratitic precipitates, flare-cells, and microfilariae. The iris was examined for loss of pupillary frill, loss of stromal architecture, and anterior and posterior synechiae. The lens was examined for cataract. Following dilation with 10% neosynephrine and 1% mydriacyl, the fundus was examined by direct and indirect ophthalmoscopy for optic nerve changes of glaucomatous cupping, neuritis, and atrophy, and the chorioretina was examined for atrophic and proliferative changes.

1. Barkaimai: Dr. Ganley was at Barkaimai only on 7 December--the team's last day there, when many patients had already received three consecutive daily treatments with topical DEC (Table 2); and some patients were not present that day. He examined 16 of the 23 patients in Tables 1 & 2, plus additional patients 27 & 28 who had loss of vision. Table 5 gives results of ophthalmic examinations of these 18 individual patients; and Tables 7, 9, 10 & 11 give combined data in comparison with results at Lugbeyee and Mawua.

- II. I. 2. Lugbeyee: On 9 December a preliminary examination was made of as many blind subjects as possible in Lugbeyee. These individuals were examined by handlight and direct ophthalmoscopy only; visual acuity was tested by finger counting, hand motion, or light perception. They were then asked to come to the school master's house for complete eye examinations, but few showed up. Eye examinations were continued at the school building on 10-11 December. Altogether Dr. Ganley gave complete ophthalmic examinations to 21 of the 34 patients studied by the rest of the team (Tables 3 & 4), plus 9 additional individuals with loss of vision--now designated patients No. 66-74. Table 6 gives results of ophthalmic examinations of these 30 individual patients; and Tables 7, 9, 10 & 11 give combined data in comparison with results at Barkaimai and Mawua.
3. Mawua: During 14-18 December, Dr. Ganley gave ophthalmic examinations at the village of Mawua, in collaboration with Drs. Büttner, Albiez and others at LRU-TIH (Sections I.D.2 & II.C). Mawua is located about 11 miles by road northwest of the Bong Iron Mine and is about 400 meters from the St. Paul River (Map 5). Mawua is village #46 in Frenzel-Beyme, 1975a who reported skin snip positivity in 58 of 85 villagers examined (56%)--out of a total population then of about 238, during 1968-71. More recently Dr. Albiez and coworkers have enumerated the village, and provided data from examination of 293 out of an estimated present population of 310 inhabitants (Tables 8a & 12a): 72% of the villagers (99% of those above age 30) had microfilariae of O. volvulus in skin snips of the hips; and 52% had nodules.
- Dr. Ganley gave complete ophthalmic examinations to 76 villagers in Mawua (Tables 7d, 8b, 9e, 10d, 11c and 12b). The basic examination was identical to that performed in Barkaimai and Lugbeyee, except for the use of the 6/60 "E" (see above). The patients were asked to keep their heads between their knees for 5-10 minutes prior to slit lamp biomicroscopy, to facilitate

concentration of microfilariae in the anterior chamber. Table 7d gives combined data on frequencies on ocular onchocerciasis by age distribution-- rather than individual data for all 76 patients (whereas individual data were given in Tables 5 & 6 for Barkaimai and Lugbeyee). But Table 11c gives individual data on 9 inhabitants of Mawua who suffered from loss of vision, and who have subsequently been designated patients No. 75-83. Skin snips were also taken from the outer canthi of 25 patients and the microfilariae counted after 24 hours in saline. The 2% DEC in Nivea Milk was applied topically to the faces of four individuals for two days, and anterior segment biomicroscopy was then obtained on the third day.

II. J. Parasitology (Drs. Schiller & Cupp)

1. Skin snips--microfilarial counts: As a routine procedure, skin snips were obtained with a scleral punch from the mid-anterior region of the left and right thighs of patients having clinical signs and symptoms of onchocerciasis. Each snip was immersed in water or physiologic saline contained in individual wells of a Belco culture plate. The wells were examined with a dissecting microscope for the presence of microfilariae of O. volvulus. Microfilarial counts of the skin snips were first made after about 15-30 minutes; and again after a period of up to 9 hours. The skin snips were then fixed in formalin for histopathologic studies (Section II.H.2). Tables 1 & 3 give microfilarial counts of skin snips from patients at Barkaimai and Lugbeyee.
2. Skin tests--sensitivity to microfilarial exoantigen: The microfilarial exoantigen was prepared in Dr. Schiller's laboratory at Johns Hopkins University. It was produced by microfilariae of O. volvulus cultivated in vitro. The exoantigen was separated from the culture medium, lyophilized, and reconstituted in phosphate-buffered saline. Aliquots of this exoantigen solution ; (0.5 ml aliquots @ 1.2 mg protein/ml) were taken to Liberia. They

were refrigerated as much as possible--in refrigerators at Monrovia, Voinjama and Yekepa; and in a styrofoam cold box at Barkaimai and Lugbeyee. For each skin test, a 0.5 ml aliquot of the exoantigen solution was injected into the skin of the volar surface of the right arm of the patient. An equal volume of the same phosphate-buffered saline, containing no exoantigen, was injected into the volar surface of the left arm, as control. Intradermal reactions were recorded after about 10 minutes. The size of the wheal (if any) was recorded, and is listed in Tables 1 & 3. Biopsy specimens were taken of the wheals that developed in patients 15 & 19 (Table 2).

II. J. 3. Blood specimens--immunochemical studies: Blood was drawn by venipuncture from 19 of the 23 patients at Barkaimai; and from 15 of the 34 patients at Lugbeyee (Tables 1 & 3). After separation, the serum was transferred to sterile screw-capped polyethylene vials and stored under refrigeration, where possible, for subsequent immunochemical studies of Onchocerciasis by Dr. Schiller at the Johns Hopkins University (still pending).

K. Entomology (Drs. Cupp & Schiller)

1. Examination of ecological settings for sibling species of *S. damnosum*:

The entomological literature regarding onchocerciasis in Liberia is quite well developed as a result of the excellent work by Dr. Rolf Garms and associates at LRU-TIH (Garms & Post, 1967; Garms 1972, 1973a,b,c, 1974; Vajime & Dunbar, 1975; Garms & Vajime, 1975; /see also Section I.D.2). Garms & Vajime, 1975 describe the occurrence of sibling species of the Simulium damnosum complex in Liberia and the ecological settings which typify each cytotype. Dr. Büttner also gave the team specific information about rivers and sites where Garms had identified the respective sibling species (Section II.C). With this information as a reference, site visits were made to several rivers and creeks to compare the general ecological-geophysical characteristics of each; these sites are shown in Map 4.

- II. K. 1. a. Sites of *S. sanctipauli*: The cytotype *Simulium sanctipauli* is named many of for the St. Paul River--where/its major breeding sites are located. The water course is much wider and usually lacks the constant shade associated with breeding sites of *S. yahense*. Sites #1-3 on the St. Paul River near Hendi (Maps 4 & 5) are in the region originally studied by Garms, 1973. Dr. Büttner showed them to team members on 29 November (Section II.C). Site #4 is much farther upstream on the St. Paul River at Beyanstown, and was visited by the team 2 December, enroute to Voinjama. A view of the river from site #4 is shown in Fig. 18. This site is at the north side of the bridge from the Tolbert Farm to Beyanstown. Very few flies were caught at site #4 from volunteer fly boys from Beyanstown, evidently because it was too late in the morning.
- b. Sites of *S. yahense*: The cytotype *Simulium yahense* was named for Yaa Creek, south of the Nimba Range (Maps 4 & 5)--where the breeding site of *S. yahense* was originally described by Garms & Vajime, 1975. On 11 December Drs. Björkman and Wilcox of LAMCO Hospital took Drs. Cupp and Schiller to site #9 on Yaa Creek near Zogowe--shown in Fig. 19. This type locality of *S. yahense* is a narrow, heavily-shaded body of water--in contrast to the wide, poorly-shaded river sites of *S. sanctipauli* described in (a) above. There was no attempt to catch flies at site #9. Hundreds of black flies believed to be *S. yahense* had previously been caught, however, at sites #5-8 having ecological settings similar to Yaa Creek. Site #5 was at Bene Creek at the bridge just north of the village of Konia (Maps 2 & 4). The team stopped at site #5 enroute to Voinjama on 2 December, and Drs. Cupp and Schiller returned there on 3 December. On both days hundreds of black flies were caught

after feeding on untreated boys from the village of Konia. Site #6 was on the south side of the bridge over the Lawa River, about two miles south of Barziwehn. Four flies that had fed on one boy were caught at site #6. Site #7 was along the Lofa River at Barkaimai (Maps 2 & 4). Hundred of black flies were caught after feeding on the treated or untreated legs of selected patients treated with topical DEC or with Nivea Milk (Sections II.E and II.G.1) ^{Table 13.} Site #8 was along the Baa River at Lugbeyee (Maps 3 & 4). Selected patients with positive skin snips, and treated with topical DEC, were taken to the river--but only a few flies were caught at site #8. These xenodiagnostic studies are described in more detail in Section II.K.3.

II. K. 1. c. Sites of *S. damnosum* (s.s.): The cytotype *Simulium damnosum* (s.s.) has been described as having larval breeding sites in Liberia along the St. John and Cestos Rivers (Garms & Vajime, 1975). The aquatic habitat of the immature stages of this cytotype is a large river in forested zones, although this cytotype can also be found in dam spillways of irrigation systems. On 11 December, enroute from Yekepa to Monrovia, the team visited site #10 at the bridge over the St. John River near Baila (Maps 1 & 4). Fig. 20 shows a view of the river at site #10. No black flies were caught there. The team did not have the opportunity to see the aquatic habitats of *Simulium soubrense* in the Cestos River--along the southeastern border of Nimba County.

2. Procedures for catching black flies: Clear plastic tubes were used to collect black flies, after feeding on the legs of treated or untreated persons at the various sites #4-8 (Section II.K.1.b). After the flies were completely engorged they detached themselves from the skin and flew

up into the tube--at which point the tube was capped. Protruding from the closed end of the tube was a filter paper wick for feeding the flies with sugar water, as necessary. The tubes were taken to the "laboratory" (at the USAID guest house/Voinjama; or at LAMCO Hospital), where the black flies were examined and dissected under a dissecting microscope. The flies were initially identified using the diagnostic characters for the Simulium damnosum complex suggested by Crosskey, 1955 & 1956: the presence of a hair-crest on the front tarsi and a white band on the hind basitarsi.* A further sibling designation could not be made with certainty; but based on the ecological descriptions of larval habitats by Garms & Vajime, 1975 it was assumed that the biting form was S. yahense at sites #5-8 on the narrow, shady Bene Creek, Lawa River, Lofa River and Baa River (Maps 2, 3 & 4; Section II.K.1.b).

II. K. 3. Xenodiagnostic assays: Black flies were collected after they obtained a blood meal from patients treated with topical DEC, or with control Nivea Milk. The flies were collected from the treated and untreated legs of patients known to be infected with O. volvulus on the basis of skin snips. Following 2 or 3 treatments on consecutive days, at least 8 black flies were collected from the treated right leg and at least 5 black flies, from the untreated left leg of each patient. Approximately 5 to 12 hours later these flies were dissected and examined for the presence of microfilariae of O. volvulus in the blood meal and the thoracic musculature, as well as for larvae in advanced stages of development. Data on numbers, location, motor activity and stage of larval development were recorded. Table 13 summarizes xenodiagnostic assays for patients No. 12, 13 & 17 at Barkaimai.

* Characteristics of the S. damnosum complex are discussed further in Garms & Post, 1967; Garms, 1973c; Garms & Vajime, 1975; Quillevere et al, 1976a,b & 1977a,g; and Vajime & Dunbar, 1975.

II. L. Photography

1. Scenic photographs: Candid 35-mm color positive transparencies were taken by Drs. Cupp, Ganley and Schiller. Dr. Gibson took (8 x 8 cm) color polaroid SX-70 Land photographs. Subjects included scenery, study sites, members of the team at work, and breeding sites of Simulium species.
2. Clinical photographs: Dr. Connor took large format (2-1/4" x 2-3/4") color positive transparencies and monochrome negatives of many of the pertinent lesions. Approximately 56 different views of patient's lesions were photographed: 7 frames of each view (5 color and 2 BW) for a total of 392 exposures. The cameras were Linhof Super Technicas (2), and the light source was a 510-volt electronic flash. Films were EPR 220 and PXP 220. All lesions were framed and focused on ground glass and exposures made with polaroid filters over the light source and over the lens--with the filters crossed so as to control highlights and to increase color saturation. The polaroid filters were set at about 75° of darkening. The exposure was adjusted by first making pilot photographs on polaroid film with the same emulsion speed (ASA 75). Identification polaroid photographs (face only) were also taken of patients. The photographs were subsequently used to correlate the clinical changes with the histopathologic changes.
3. Photomicrographs: Drs. Connor and Gibson, assisted by the AFIP Photography Department, took photomicrographs of histopathologic features from the biopsy specimens. An optical bench equipped with an automatic exposure meter was used to take color transparencies (4" x 5") as well as black and white negatives. Black and white enlargements (8" x 10") were made for use in this report. The legends cite the AFIP Negative No. of the photograph, as well as the AFIP Accession No. of the patient.

II. M. Conference of team with MOH, LIBR, and USAID officials, in Monrovia

Following our research studies up-country in Barkaimai and Lugbeyee, the team returned to Monrovia the evening of 11 December. This allowed three days for work on a preliminary draft report, before most of the team was to depart for the U.S.A. late on 14 December. The team decided it would be very beneficial to hold a high level conference during this period, to verbally report our findings and recommendations, and to learn more about the policies of the Government of Liberia and USAID/Monrovia regarding the health care system in Liberia and the control of parasitic diseases. The team had accordingly sent a letter on 5 December from Voinjama to Deputy Director Anderson of USAID/Monrovia--requesting that he set up such a conference between the team and officials of the Ministry of Health and Social, USAID, LIBR, LRU-TIH, and others interested in the control of onchocerciasis in Liberia (Sections II.A-C).

The conference was held at the MOH on 13 December, between 1000 to 1300 hours.

In attendance were:

1. The Onchocerciasis Team for Liberia: Drs. Connor, Cupp, Ganley, Gibson and Schiller;
2. Ministry of Health and Social Welfare: Dr. Swamy, Director/Bureau of Preventive Services; Dr. Holder, WHO Coordinator; Mr. Clark, Division of Communicable Diseases;
3. Liberian Institute of Biomedical Research: Dr. Dennis, Director/LIBR; Dr. van den Ende, Researcher;
4. USAID/Monrovia: Mr. Marsh, Senior Program Officer; Mr. Hagel, Program Officer;
5. Liberia Research Unit, Tropical Institute Hamburg: Drs. Büttner and Albiez, General Medical Officers.

The results of the conference are incorporated into the Discussion and Recommendations (Section IV; and Summary, p. i-iv).

II. N. Preparation of Report

1. Preliminary Draft Report: During 12-14 December, the team prepared a preliminary draft report--with secretarial assistance from the USAID Mission in Monrovia. Copies were left with Deputy Director Anderson of the USAID Mission, for limited distribution to some of those attending the conference (Section II.M) as well as to other GOL officials.
2. Final Draft Report: During December, 1978 to February, 1979 the team members worked on changes in their sections of the report--at their respective institutions in the U.S.A. Additional data and discussion not in the preliminary draft report were compiled and inserted into the final draft report--including sections on histopathologic diagnoses of the skin biopsy specimens at AFIP; and the ophthalmic examinations of Dr. Ganley at Mawua (Sections II.H.3, II.I.3, III.D.2, III.F.2, III.G.2, III.I.3; Tables 2, 4-12). Editorial changes and additions were sent to the Team Leader, Dr. Connor, for incorporation into the final draft report by Drs. Connor and Gibson. Copies of the final draft report were sent out during 2-9 March 1979 for review by APHA, USAID/Washington, and other members of the team.
3. Final Meeting of Team with APHA and USAID: The team was again assembled in Washington, D.C. on _____ with officials of the APHA and USAID/Washington. The trip to Liberia was reviewed, and necessary changes were made in the final draft report.
4. Final Report: Based on corrections to the final draft report made in this meeting (3 above), a final report was prepared, and submitted to APHA on _____.

III. FINDINGS

A. General Findings at Barkaimai

1. Screening for signs and symptoms of onchocerciasis (Section II.E):

More than 60 adults from Barkaimai were screened for signs and symptoms of onchocerciasis, and 22 were selected for more study and treatment. In addition, Dr. Camanor of Voinjama Hospital (patient No. 24) was given the skin test and had his blood drawn. Table 1 gives general data on the patients, including the AFIP Accession Number, age, sex, skin snip and skin test results, and the signs and symptoms of onchocerciasis. Of the 22 patients, 16 had one or more onchocercal nodules. There were clinical signs of onchocercal dermatitis in 17 patients; and fullness of the inguinal or femoral regions in 15 patients. These clinical pathologic findings are described in more detail in Section III.C.

2. Demography--age and sex: There were 16 males and 7 females, between the ages of 20 and 90 years. The number in each age-decade were: 3 patients in the 20's; 4 in the 30's; 5 in the 40's; 3 in the 50's; 2 in the 60's; and 1 each in the 80's and 90's. The median age was 46. The team made no effort to enumerate the village of Barkaimai, though there were estimated to be about 900 inhabitants during 1968-71 (village #7 in Frentzel-Beyme, 1975a). We also don't know the age distribution of the village as a whole. The younger males and females tended to be harvesting crops and were thus less available for treatment and followup--so our sample is probably older than the village as a whole. We did not study any children, who are a large percentage of most Liberian villages. (For example, 47% of the villagers of Mawua are under age 20, as shown in Table 12a.) A few of the patients at Barkaimai were treated with topical DEC, but were subsequently absent one or more days for farming or personal reasons (Table 2).

III. A. 3. Skin snips and skin tests: Only 6 of the 21 patients tested at Barkaimai had microfilariae of O. volvulus in skin snips of one or both thighs. After the snips had been counted, they were fixed in formalin and subsequently embedded in paraffin. Light microscopic studies at AFIP revealed numerous microfilariae remaining within the snips. Many of the villagers with negative skin snips none-the-less had onchocercal nodules and dermatitis characteristic of onchocerciasis. The water or saline may have contained a substance that inhibited the emergence of microfilariae from the snips.

In contrast, 18 of the 21 persons tested were sensitive to the microfilarial exoantigen used for skin tests (Table 1). This included Dr. Camanor, Patient No. 24, who had no clinical manifestations of onchocerciasis, but was originally from Foya Kamara--known to be endemic for onchocerciasis (Frentzel-Beyme, 1975^a; LRU-TIH Annual Reports for 1977 & 1978). Patients No. 5, 7 and 8 had negative skin tests, though all had nodules and No. 8 had a positive skin snip. Some of these patients may have "burned-out" onchocerciasis as indicated by their age and calcified nodule(s). Those with positive skin tests developed a wheal measuring between 10 and 22 mm (Table 1). The wheal appeared within 10-15 minutes after injection of the exoantigen, then faded within a period of a few hours. Histopathologic findings in the wheals from patients No. 15 and 19 are discussed further in Section III.G.

Comparison of the results indicates that the skin test with microfilarial exoantigen is a much more sensitive indicator of onchocerciasis than is the microfilarial count of skin snips.

III. B. General Findings at Lugbeyee

1. Screening for signs and symptoms of onchocerciasis (Section II.F):

Approximately 50 adults from Lugbeyee were screened for signs and symptoms of onchocerciasis, and 34 were selected for more study and treatment.

Table 3 gives general data on these patients, including the AFIP Accession Number, age, sex, skin snip and skin test results, and the signs and symptoms of onchocerciasis. Of the 34 patients, 27 had one or more onchocercal nodules. Onchocercal dermatitis was noted in 14 patients;

and a few patients had eye examinations only (Tables 3 & 6). Fullness of the femoral or inguinal nodes were noted in 10 patients. These clinical pathologic findings are described in more detail in Section III.C.

2. Demography--age and sex: There were 26 males and 8 females, between the ages of 26 and 70 years. The number in each age-decade were: 3 patients in the 20's; 7 in the 30's; 5 in the 40's; 10 in the 50's; 8 in the 60's; and 1 in the 70's. We don't know the age distribution of the village as a whole; but as for Barkaimai, we studied no children of Lugbeyee, who are expected to be a large percentage of its population. The median age of those studied was 50. There were estimated to be about 750 inhabitants of Lugbeyee during 1968-71 (village #101 in Frentzel-Beyme, 1975a). The villagers were predominantly farmers, and 10 patients who were treated with topical or intradermal DEC didn't return for followup on one or more days (Table 4).

3. Skin snips and skin tests: There were microfilariae of O. volvulus in skin snips of one or both thighs of 14 of the 15 patients tested at Lugbeyee. The counts for patients No. 33, 35 and 40 were much higher than for patients No. 6, 12 and 17--the three highest counts in Barkaimai (compare Tables 1 & 3). The high skin snip positivity (93%) agrees well

with the report that more than 90% of the villagers above age 90 had positive skin snips (Frentzel-Beyme, 1975a).

Of the 15 patients injected with microfilarial exoantigen, 12 developed well-defined wheals within 10-15 minutes; 2 were "doubtful positive"; and 1 was negative. These wheals measured between 10 and 26 mm, and the largest ones were larger than those at Barkaimai (Tables 1 & 3). It is interesting to note that patient No. 43 had the largest wheal, multiple nodules, gale filarienne, and bilateral femoral lymphadenopathy--but his skin snips were negative. In contrast, patient No. 39, whose skin test was negative, had no nodules or lymphadenitis--but did have gale filarienne and only a weakly positive skin snip. The skin test with microfilarial exoantigen again appears to be a much more sensitive indicator of onchocerciasis than is the microfilarial count in skin snips.

C. Clinical Pathologic Findings at Barkaimai and Lugbeyee (Tables 1 & 3)

1. Pruritus, onchocercal dermatitis and gale filarienne: Most of the 56 patients with onchocerciasis studied at Barkaimai and Lugbeyee had the same general changes in the skin as have been previously reported for patients in Zaire, Cameroon and other African countries (Connor et al, 1970; Gibson et al, 1976; Gibson & Connor, 1978). Itching was the dominant subjective manifestation. Most patients claimed to itch all over (trunk, head & limbs) but on questioning claimed most intense itching to be on the buttocks, lower trunk and thighs. Wrinkling, atrophy and/or scaling of the skin of the thighs, knees, shins and buttocks were common findings (Fig. 8). There was frequently hypo- or depigmentation of the skin of the shins; and patients No. 19 & 60 also had depigmentation of the male genitalia (Tables 1 & 3). There ^{were} also several patients who

had the features of "gale filarienne"--characterized by discrete papules of lower trunk, pelvic girdle and upper thighs. The early lesions were up to 0.2 cm, raised, pointed, pruritic and surrounded by scratch marks. Older lesions were crusted, scaling with silvery white scales, and sometimes infected. Fig. 5 shows the gale filarienne of the left thigh and hip of patient No. 13.

III. C. 2. Nodules: There were one or more typical onchocercomas in 43 (77%) of the 56 patients studied at Barkaimai and Lugbeyee (Tables 1 & 3; Figs. 5 & 8). They were non-tender, freely moveable nodules in the subcutaneous connective tissue--almond shaped and up to 3 cm across; sometimes discrete, and sometimes clustered. Patients were usually aware of these "worm nodules" and frequently located them for us. Only rarely did we encounter a nodule of which the patient was unaware. They mistook, however, other cutaneous lesions such as epidermal inclusion cysts and lipomas for "worm nodules".

The nodules were most numerous over the anterior superior iliac spines, the greater trochanters, the sacrum and the coccyx. Fewer nodules were situated between the iliac spines and trochanters, in the soft tissues of the buttocks and over the ribs between the anterior and posterior axillary lines. Especially striking was the finding that 11 (32%) of the patients at Lugbeyee, but only 2 (9%) of those at Barkaimai, had large clusters of onchocercal nodules over the sacrum--bisecting or deviating to produce the "Fuglsang sign", shown in Fig. 8. The skin over some nodules was irregularly scarred, suggesting native treatment such as puncture, branding, etc. In this small sample of patients we found no nodules over the ankles, knees, scapulae, or on the head.

III. C. 3. Lymphadenopathy: The femoral and inguinal lymph nodes were enlarged in at least 25 (45%) of the 56 patients at Barkaimai and Lugbeyee (Tables 1 & 3). There was usually a dominant node up to 1.5 cm maximum; and all enlarged nodes were non-tender, soft, freely moveable and less than 1.5 cm maximum. Some patients had early hanging groins over clusters of enlarged nodes-- as illustrated for Patient No. 13 in Fig. 5. The clinico-pathologic features of onchocercal lymphadenitis are described by Gibson & Connor, 1978. None of the villagers seen at Barkaimai or Lugbeyee had elephantoid changes of the male genitalia, or fully developed hanging groins--as described for patients in Zaire, Cameroon and other African countries by Gibson & Connor, 1978. The team took no biopsy specimens of enlarged lymph nodes from the Liberians. The femoral or inguinal lymph nodes of several patients became tender and painful following topical, oral or intradermal treatment with DEC.

D. Reactions to Topical DEC

1. Clinical findings: The lotion of 2% DEC in Nivea Milk was rubbed over the right legs of 10 patients at Barkaimai and 16 patients at Lugbeyee; and both legs of patient #40 were inadvertently treated (Tables 2 & 4). Most were given multiple treatments on two or three consecutive days. Three of the 26 topically treated patients did not return for followup (11%; patients No. 33, 44 & 65); and seven patients showed no change in the treated right leg (27%; patients No. 1, 5, 9, 19, 42, 43 & 45). These "non-reacters" had negative skin snips of both thighs, excepting low microfilarial counts for patients No. 42 & 45 (Tables 1 & 3). The remaining sixteen (62%) developed itching of the entire treated limb, within a few hours--but no change in the untreated limb or elsewhere on the body. Eight of these developed pruritus only--without papules or other objective changes in the skin of the treated limb (31%; patients No. 10, 32, 35, 37-41).

These "moderate reactors" generally had low microfilarial counts in skin snips of both thighs--excepting the very high counts for patients No. 35 & 41. Eight others developed pruritus within a few hours, and by 24 hours had developed a confluent area of eruption characterized by edema, some erythema, and fine papules (31%; patients No. 6, 12, 13, 14, 17, 31, 34 & 36). These "severe reactors" generally had moderate to high microfilarial counts in skin snips of the thighs--excepting the negative count for patient No. 14. (All of these "non-, moderate, and severe reactors" had positive skin tests to microfilarial exoantigen, excepting "non-reacter" patient No. 5.)

The papular eruption in "severe reactors" was generally limited to the anterior upper thigh, roughly triangular in outline with the base along the inguinal ligament--the upper limit of topical application of DEC. This triangular area of skin probably had a higher concentration of microfilariae than the remainder of the treated leg. The papular eruptions on the treated right thighs of patients No. 12, 17 and 34 are shown in Figs. 3, 4, 6 & 7. These eruptions contrast with the smooth skin of the untreated left thighs--indicating little or no systemic distribution of DEC within the times studied. (Some patients complained of generalized itching after topical DEC, but these patients pointed to the right thigh and leg when asked about the area of most severe itching; no papules, erythema or swelling occurred outside the treated area.) The papular eruptions persisted for the 2-3 days of observations, and usually became more severe after multiple applications. This is illustrated in Figs. 3 & 4 for patient No. 12 after one and three treatments. By the third day large papules up to 2 mm across developed, one of which was biopsied at 71 hours (biopsy 12B; Figs. 12-15; Section III.D.2). The edema at 71 hours is indicated by the 20.5-inch circumference of the treated right thigh, compared to 19.5 inches for the untreated left

thigh. Erythema was a common feature of the treated thighs of "severe reactors"; but this was especially pronounced for patient No. 13, whose right thigh was quite hot to the touch--described as "brawny hot edema".

Nivea Milk containing no DEC was rubbed over the right legs of four control patients at Barkaimai (patients No. 2, 3, 20 & 21)--none of whom developed any pruritus, papular eruptions, or other changes seen after the topical application of DEC in Nivea Milk.

III. D. 2. Histopathologic findings: Biopsy specimens of skin were taken from both treated and untreated thighs, after one to three daily topical applications of DEC (Section II.H.2). There were no specimens from "non-reacters".

a. "Moderate reactor"--3 days: There was one biopsy specimen (10A; Table 2) from a "moderate reactor", taken at 67 hours--after three topical applications of DEC to patient No. 10. Microscopic examination revealed only mild chronic inflammation of neurovascular channels of the upper dermis, but few eosinophils; occasional microfilariae within the upper dermis--showing no degenerative changes; and no intra-epidermal vesicles or other changes in the epidermis.

b. "Severe reactors"--1 day: Biopsy specimens 12A, 17A & 36A were taken from treated thighs of "severe reactors", patients No. 12, 17 & 36, 22-23 hours after a single topical application of DEC; and specimen 36B was from the untreated left thigh at the same time (Tables 2 & 4). Microscopic examination of 12A, 17A & 36A revealed moderately heavy chronic inflammation of neurovascular channels of the upper dermis--including large numbers of eosinophils, many of which were "degranulated"; multiple areas of necrosis containing degenerating microfilariae of

O. volvulus; viable microfilariae, sometimes in dermal papillae just beneath the epidermis, but sometimes penetrating into the basal layer; and a few intra-epidermal vesicles containing fragments of degenerating microfilariae. Control specimen 36B taken from the untreated left thigh (23 hours after topical application of DEC to the right leg) revealed only mild chronic inflammation of neurovascular channels, with very few eosinophils; no foci of necrosis or degenerating microfilariae; few viable microfilariae in the upper dermis; and no intra-epidermal vesicles.

III. D. 2. c. "Severe reactors"--2 days: Biopsy specimens 6A, 13A, 14A & 31A were taken from treated thighs at 45-49 hours, after two topical applications of DEC; and specimen 14B was from the untreated thigh at the same time (Tables 2 & 4). Microscopic examination revealed more severe forms of the changes described in (b) after 1 day. In particular there were more areas of necrosis containing degenerating microfilariae, and intra-epidermal vesicles were much more frequent in specimens 13A & 31A. A typical section from specimen 13A (6-mm wide) showed 5 vesicles ranging between 50-80 microns across. A typical section from specimen 31A (6-mm wide) taken through a clinical "papule" showed a very large intra-epidermal vesicle about 1-mm across and divided into three compartments; plus six smaller vesicles ranging between 60-250 microns. Fig. 16 shows a vesicle of about 240 microns in specimen 31A; the vesicle is being penetrated by a microfilaria of O. volvulus. These vesicles contain large numbers of eosinophils and neutrophils and can thus be called intra-epidermal abscesses. The chronic inflammation of the neurovascular channels of the upper dermis also included numerous eosinophils--but we found very few neutrophils in the dermis following topical application of DEC.

Control specimen 14B from the untreated left thigh (48 hours after topical treatment of the right leg) showed none of these changes, and was similar to specimen 36B in (b) above. (A few microfilariae were seen in specimens 14A & B, even though the skin snips of both thighs had negative counts; Table 1.)

III. D. 2. d. "Severe reactors"--3 days: Biopsy specimens 6B & 12B were taken from treated thighs at 70-71 hours--after three topical applications of DEC (Table 2). Figs. 4 & 12 show the clinical picture of the papular eruption, and the cut surface of specimen 12B through a large papule (vesicle) that is about 2.0 mm across and 0.7 mm deep. Microscopic examination of this specimen revealed a very large vesicle divided into two compartments, one of which contained a microfilaria--as shown in Figs. 13 & 14. Sections stained by H & E, Giemsa and Russell-Movat stains reveal that the vesicle contains fibrin, inflammatory mucin and fluid, in addition to eosinophils, neutrophils and desquamated epidermal cells. Fig. 15 shows a degenerating microfilaria within a smaller intra-epidermal abcess of the same specimen. Microscopic examination of specimen 6B revealed less reaction than in specimen 12B, but more than in specimen 6A (45 hours; (c) above). The vesicles in specimen 6B ranged between 100-200 microns across, and generally contained degenerating microfilariae.

Reaction):

3. Comparisons to reactions to oral DEC (Mazzotti): The papular eruption seen clinically after topical application of DEC, and the vesicles seen by histopathologic examinations, have previously been observed in some patients treated with oral DEC--as reported by Connor et al, 1970 and WHO, 1974. Pruritus is likewise common to both modes of administering DEC. But the reaction is more localized with topical application, in

contrast to the systemic effects of oral DEC. The papules and vesicles may be somewhat more numerous after topical application, perhaps because it results in a higher concentration locally in the upper dermis and in the epidermis.

III. E. Reactions to Oral DEC

1. Clinical findings: Severe, generalized pruritus (Mazzotti reaction) developed in patients No. 16 & 21 given a single 100-mg oral dose of DEC (banocide), as well as in patient No. 23 given two such daily doses. The most severe reaction was bilateral periorbital edema that developed in patient No. 16 (Tables 2 & 5; Section III.I.1).
2. Histopathologic findings: A 4-mm punch biopsy specimen of the skin of the swollen left outer canthus was taken from patient No. 16, 24 hours after her oral dose of DEC. Microscopic examination revealed severe edema with dilated lymphatic vessels in the upper dermis. The Russell-Movat stain revealed large amounts of muco-saccharides. Within the neurovascular channels and around the follicles and glands there was a chronic infiltrate that included especially large numbers of plasma cells and lymphocytes, but few eosinophils. (Large numbers of eosinophils are commonly seen in other cases after oral or topical DEC.) The Giemsa stain revealed large numbers of mast cells as well. A careful search of ten sections revealed no intact microfilariae, but there was a focus that appeared to contain nuclei of a degenerating microfilaria near a gland. The lack of large numbers of microfilariae in the outer canthus contrasts with the numerous microfilariae and punctate opacities seen in both corneas (Table 5; Section III.I.1). This suggests that the periorbital edema resulted from an immune response to soluble microfilarial antigens, rather than to intact microfilariae--although we have no pre-treatment specimen from the

outer canthus. There might also have been post-treatment migration of microfilariae from the canthi into the corneas. (Microfilariae were not seen in skin snips of both thighs, before treatment; but she developed a wheal on the arm after injection of microfilarial exoantigen--Table 1 and Section III.A.3.)

III. F. Reactions to Intradermal DEC

1. Clinical findings: An intradermal injection of 25 mg DEC was given to 16 patients at Lugbeyee (patients No. 47 & 50-64; Table 4). Patients No. 53 & 64 didn't return for follow-up, and No. 55, 56 & 62 showed no pruritus or other reaction. The remaining 11 patients developed generalized pruritus, with maximum itching often near the site of injection of the thigh. But severe itching also developed at sites remote from the injection, especially over papules and onchocercal nodules of the buttocks and iliac spines in No. 54 and 58. The itching began as early as 15 minutes after injection in some patients, and was still severe after 20-24 hours in most--but seemed to have subsided in patient No. 54. The sites of injection generally became swollen and indurated, and blisters developed over these sites in No. 59 & 63 (Section III.F.2 below)--the clinical appearance of which are shown in Figs. 9 & 11. The areas of induration were about 25 mm across, and the blisters were 4-6 mm across. Skin snips were not taken from any of the patients given intradermal DEC, so we can't correlate differences in the severity of the reactions with numbers of microfilariae in the skin of the thighs.
2. Histopathologic findings: Biopsy specimens of skin were taken from four of the sixteen patients given intradermal injections of DEC, as given in Table 4. Biopsy specimen 57A was taken through a papule on the buttock of patient No. 57, 90 minutes after intradermal injection of DEC into his left thigh. Microscopic examination revealed a chronic

infiltrate of the neurovascular channels, inflammatory mucin (revealed by the Russell-Movat stain), and occasional intact microfilariae in the dermal papillae.

Biopsy specimens 50A & B were taken from the right and left thighs, 18 hours after intradermal injection of DEC into the left thigh. Clinically there was more reaction in the treated thigh than in the untreated one.

Microscopic examination of specimen 50A from the untreated thigh revealed chronic inflammation of the neurovascular channels--especially with numerous plasma cells and lymphocytes, but only a few eosinophils; and numerous intact microfilariae in the upper dermis, but none that were degenerating. Examination of specimen 50B from the injection site revealed a slight blister (not noted clinically); severe chronic inflammation of the neurovascular channels, with numerous plasma cells and lymphocytes, and many-fold more eosinophils than in specimen 50A; and numerous degenerating microfilariae but few intact microfilariae in the upper dermis.

Biopsy specimens 59A & 63A were taken through blisters at the injection sites, 20 hours after intradermal injection of the right and left thighs of patients No. 59 and 63, respectively. Fig. 10 shows a cross section of specimen 59A. Both specimens had a hyperemic dermis that was firmly attached to, but sharply delimited from the underlying lobulated fat. Microscopic examination revealed a denuded epithelium, with the keratin and part of the prickle cell layer lifted off--erosion of the epithelium being greater for specimen 59A than 63A. Both showed mixed acute and chronic inflammation widely distributed throughout the upper dermis, and containing large numbers of neutrophils as well as eosinophils; specimen 63A also had large numbers of plasma cells in this infiltrate.

The large numbers of neutrophils are in marked contrast to their minimal presence in specimens from patients treated with topical or oral DEC. Specimens 59A & 63A both had numerous degenerating and intact microfilariae in the dermal papillae, extending through the denuded epithelium, and also within the lumen of the blister. There were also microfilariae much deeper, around the lobulated fat--and most of these were degenerating microfilariae. The Russell-Movat stain revealed fibrinoid strands and globular material amongst this fat--some of which material is believed to be immune complex involving microfilarial antigens (cf Gibson & Connor, 1978).

III. G. Reactions to Injection of Microfilarial Exoantigen

1. Clinical findings: At Barkaimai and Lugbeyee, a total of 36 patients were injected with the microfilarial exoantigen; and 30 (82.5%) developed a wheal measuring between 10 and 26 mm (Tables 1 & 3; and discussed for the separate villages in Sections III.A.3 & III.B.3). The 10 x 13 mm wheal on the right arm of patient No. 17 can be seen in Fig. 6--in contrast to the site of control saline injection on the left arm.
2. Histopathologic findings: Biopsy specimens 15A & 19A were taken through the wheals, 25 and 50 minutes after injection of microfilarial exoantigen into the right arms of patients No. 15 & 19, respectively (Table 2). The 6-mm punch biopsy specimens were taken through wheals measuring 16 x 17 mm and 18 x 20 mm, respectively. The cut surface of specimen 19A was noted to show an indistinct line between the dermis and the underlying fat ("fusion"). Microscopic examination revealed edema and hyperemia of the dermis; and a chronic infiltrate consisting mostly of eosinophils, in and around small vessels of the mid-dermis. This is illustrated for specimen 19A, in Fig. 17. The vasculitis was greater for specimen 19A than for 15A. The Russell-Movat stain revealed edema

containing fibrinoid material interpreted as immune complex involving the microfilarial antigen (Gibson & Connor, 1978). No microfilariae were found in either specimen--consistent with the negative microfilarial counts for skin snips from both thighs of these patients (Table 1).

III. H. Lack of Reaction to Topical Mintezol

1. Clinical findings: Liquid thiobendazol ("Mintezol") was topically applied to the right legs of four patients at Barkaimai. No subjective or objective changes were noted in either the treated or untreated legs of patients No. 8, 11 & 20; and patient No. 2 said his right leg felt "heavy" but not itchy (Table 2).
2. Histopatnologic findings: Biopsy specimen 8A was taken 22 hours after topical application of Mintezol to the right leg. Microscopic examination revealed occasional intact microfilariae, but no degenerating microfilariae. (Pre-treatment skin snips were negative for the right thigh, but positive for the left thigh; Table 1). Specimen 8A was otherwise normal skin--without chronic infiltrate or edema.

III. I. Ophthalmologic Findings:

1. Barkaimai: Ophthalmic examinations were given to 18 inhabitants of Barkaimai--16 of those studied and treated by the rest of the team (Tables 1 & 2), plus two additional patients No. 27 & 28. Tables 5, 7a, 9a, 10a & 11a give ophthalmologic findings for the individual patients and eyes, as well as frequencies of symptoms and visual acuities by age distribution. There was punctate keratitis in 9 (50%); microfilariae in the anterior chamber in 4 (22%); onchocercal chorio-retinitis in 2 (11%); and one or more of these signs and symptoms of ocular onchocerciasis in a total of 10 of the 18 villagers examined (56%)--Table 7a. None-the-less, 28 (78%) of their 36 individual eyes had visual acuity in the normal range of 6/6 to 6/12; 3 eyes (8%) had somewhat reduced acuity in the range 6/18 to 6/36; and 5 eyes (14%) had severe loss of vision to an acuity range of 1/60 to NLP (no light perception)--Table 9a. But the reduced visual acuity was caused by the ocular onchocerciasis only in the eyes of patient No. 16: 6/24 and 6/18 in the right and left eyes, respectively --Tables 5, 10a, 11a. Slit lamp examination revealed numerous microfilariae and a few punctate opacities in her corneas as well as nasal and temporal infiltrates of the corneas. She was examined 24 hours after an oral dose of 100 mg DEC, and had developed severe bilateral periorbital edema--although no intact microfilariae and only one focus with an apparent degenerating mf was seen in the 4-mm punch biopsy specimen 16A from the left outer canthus (see Section III.E.1&2). Other patients having microfilariae and/or punctate opacities in the corneas but no vision loss included patients No. 6, 12, 13 & 17--who had microfilariae in skin snips of the thighs, and were "severe reactors" to topical application of DEC (Tables 1, 2 & 5; Section III.D.2.b-d).

Other causes of reduced vision at Barkaimai included cataracts in patients No. 21 & 28; glaucoma in No. 27; and probably measles in No. 15--Tables 5, 10a & 11a. Only patients No. 27 & 28 had been selected for ophthalmic examinations because of visual loss, and they showed no overt signs of either ocular or dermal onchocerciasis. The other 16 patients had been selected by the rest of the team (before Dr. Ganley arrived) on the basis of onchocercal nodules, skin lesions, and other signs and symptoms of dermal onchocerciasis (Table 1). The age distribution of those examined included none under age 20, and was thus not representative of the village as a whole (for which we have no data). The size of the sample is too small to provide good data on age distribution of the symptoms of ocular onchocerciasis. It will be noted from Table 7a, however, that villagers aged 40-59 had higher frequencies of punctate keratitis and chorioretinitis than those aged 20-39.

III. I. 2. Lugbeyee: In a preliminary survey of Lugbeyee, Dr. Ganley examined many persons with reduced vision by handlight and direct ophthalmoscopy, and tested visual acuity by finger counting, hand motion, or light perception. A few of these later received ophthalmic examinations by slit lamp-- along with many of those selected by the rest of the team for signs of dermal onchocerciasis (Tables 3 & 4): patients No. 66-74, in addition to patients No. 31-63--as given for individual patients in Tables 6, 10b & 11b. Tables 7b & 9b give combined frequencies of signs and symptoms of ocular onchocerciasis, and visual acuity levels by age distributions-- for 23 and 30 patients from Table 6, respectively. There was punctate keratitis of the corneas in 8 (35%); microfilariae in the anterior chamber in 9 (39%); chorioretinitis in 7 (30%); and one or more of these signs of ocular onchocerciasis in a total of 13 (57%) of the

23 villagers examined by slit lamp--Table 7b. The seven patients No. 68-74 were tested for visual acuity, but weren't examined by slit lamp (Tables 6, 7b & 9b)--giving acuities for 60 individual eyes of 30 villagers. Of these, 35 (58%) had acuities in the normal range of 6/6 to 6/12; 2 eyes (3%) had somewhat reduced acuities in the range 6/18 to 6/36; 4 eyes (7%) had more strongly reduced acuities in the range 6/60 to 3/60; and 19 eyes (32%) had severely reduced acuities in the range 1/60 to NLP. The reduced acuities probably resulted from ocular onchocerciasis only in 4 eyes of 3 patients: macular depigmentation in the right eyes of patients No. 48 & 66; and chorioretinitis in both eyes of No. 52--Tables 6, 10b & 11b. Other patients having microfilariae and/or punctate opacities in the corneas, or microfilariae in the anterior chamber--but no resultant loss of vision--included patients No. 31 & 36 who were "severe reactors" to topical DEC; and No. 59 & 63 who developed blisters from intradermal DEC (Tables 3, 4 & 6). Patient No. 59, however, had no light perception in the right eye because of trauma.

Other causes of reduced vision at Lugbeyee included cataracts in the five patients No. 47, 67, 70, 72 & 73; glaucoma in No. 46 & 69; and a corneal scar probably secondary to infection in No. 74. These were patients selected for loss of vision in Dr. Ganley's preliminary survey--hence the higher frequencies than seen at Barkaimai. The age distribution of those examined at Lugbeyee likewise included none under age 20, and was not representative of the village as a whole (for which we have no data). Table 7b/^{shows} little change in punctate keratitis and microfilariae in the anterior chamber between ranges 20-39 & 40-59; but a marked increase in chorioretinitis for those over age 60.

III. I. 3. Barkaimai + Lugbeyee: Because of the small sample sizes at Barkaimai and Lugbeyee, the data were also combined for the two villages, and are presented in Tables 7c, 9c & 10c. Of 41 villagers that were given slit lamp examinations, 17 (41%) had punctate keratitis; 13 (32%) had microfilariae in the anterior chamber; 9 (22%) had chorioretinitis; and 23 (56%) had one or more of these symptoms of ocular onchocerciasis--Table 7c. Of the 96 individual eyes of 48 villagers tested for visual acuity, 66% were in the normal range of 6/6 to 6/12; 5% had somewhat reduced acuities in the range 6/18 to 6/36; 4% had more strongly reduced acuities in the range 6/60 to 3/60; and 24% had severely reduced acuities in the range 1/60 to NLP. (The high percentage in the last category resulted largely from selection of villagers with loss of vision at Lugbeyee; Table 9c.) The loss of vision resulted from ocular onchocerciasis in only 6 eyes of 4 patients--Table 10c. The remaining 19 patients with ocular onchocerciasis had normal visual acuities, and most had only a few microfilariae and/or punctate opacities in the corneas--and likewise only a few if any microfilariae in the anterior chambers. The largest causes of visual loss in Barkaimai and Lugbeyee were cataracts in 6 patients; and glaucomas in 3 patients--Table 10c.

The age distributions of the symptoms of ocular onchocerciasis are also shown in Table 7c. The frequencies of punctate keratitis were somewhat higher for ages 40-59 compared to 20-39, then decreased over age 60; and chorioretinitis increased sharply over age 60.

III. I. 4. Mawua: Dr. Albiez and coworkers at the LRU-TIH have done extensive studies of onchocerciasis in the village of Mawua (Mauwa)--for the doctoral dissertation of Dr. Albiez and other reports by Drs. Albiez, Büttner & Schulz-Key listed under LRU-TIH, 1976 & 1977 (Annual Reports). They provided data on age and sex distributions of the total village, as well as on microfilarial carriers and nodule carriers--given in Tables 8a & 12b for 293 inhabitants, out of a total population of 310 found in a survey conducted in April, 1976. During 14-18 Dec 78, Dr. Ganley gave ophthalmic examinations to 76 (26%) of the 293 inhabitants, for which the corresponding data are given in Tables 8b & 12b. The participation rate increased slightly with increasing age, probably reflecting the availability of the older group since they were not needed in the fields or were not out in the market place. None were examined under the minimum age limit of six years. In general the patients who underwent an ophthalmic examination had similar frequencies of microfilarial carriers and nodules carriers, plus mean mf per mg of hip skin snip and nodules per carrier, as for the total village (Tables 12a & b). There was some variability, as expected considering the small numbers in each age group.

Table 9e. gives visual acuity levels by age for individual eyes among the 76 villagers. 138 (91%) of the 152 individual eyes had visual acuities in the normal range of 6/6 to 6/12 (= 20/20 to 20/40); and 100% of the eyes were "normal" under age 50. There were 4 eyes (3%) with somewhat reduced acuities in the range 6/18 to 6/36; 4 eyes (3%) with more strongly reduced acuities in the range 6/60 to 3/60; and 6 eyes (4%) with severely reduced acuities in the range 1/60 to NLP--Table 9e. Tables 10d & 11c give the causes of reduced acuities for the 14 eyes (9%) with acuities of 6/18 (= 20/60) or worse. Ocular onchocerciasis probably caused the reduced acuities in only 4 of these eyes from three patients: optic atrophy in

the left eye of patient No. 75; macular depigmentation in both eyes of No. 81 and the left eye of No. 82. There were 44 other patients with evidence of ocular onchocerciasis, however, who showed no resultant loss of vision (Table 7d). Other causes of visual loss at Mawua included cataracts in No. 77, 78 & 80; traumatic cataract in No. 79; glaucoma in No. 83; and uncorrected aphakia in No. 76. Patient No. 77 had bilateral cataract extraction, but without corrective lenses; and acuity less than 6/60. Based on examination of the ocular media, Dr. Ganley anticipates that normal visual acuity should be expected with corrective lenses; so she shouldn't be considered legally blind in the absolute sense.

Table 7d gives the frequency of ocular onchocerciasis by age and sex distribution among the 76 villagers given ophthalmic examinations. The major manifestations of ocular onchocerciasis were punctate keratitis in 27 (36%); microfilariae in the anterior chamber in 35 (46%); and diffuse depigmentation or drusen-like appearance of the chorioretina in 16 (21%). Optic atrophy in one villager was probably caused by onchocerciasis (discussed below). If the patient had any of these findings in either eye, the diagnosis of ocular onchocerciasis was applied to that individual. The frequency of punctate keratitis appeared rather constant at 33-37% for the different age ranges. There was an increase in the frequency of microfilariae in the anterior chamber with age: 18% for ages 0-19; 50% for ages 20-39; 58% for ages 40-59; and 67% above age 60. The presence of diffuse depigmentation of the chorioretina also similarly increased with age: 10% for ages 20-39; 32% for ages 40-59; and 53% above age 60. The prevalence of any manifestation of ocular onchocerciasis also increased with age: 41% for ages 0-19; 65% for ages 20-39; 74% for ages 40-59; and 73% above age 60. The overall frequency of ocular onchocerciasis in the 76 villagers examined at Mawua was 62%.

Only one patient showed a suggestion of a nasal and temporal infiltrate but it was very early in its development. None showed evidence of marked sclerosing keratitis. In two, microfilariae were observed in the cornea in addition to the punctate keratitis. The number of microfilariae in the anterior chamber usually measured between 1-4 per eye when present. Seven patients had between 5-19 microfilariae in one eye, and three individuals had more than 20 microfilariae present in an anterior chamber. The maximum iris changes observed in Mawua were a slight thickening of the iris with some loss of stromal crypts and an occasional patient had some loss of the pupillary frill. No posterior or ^{anterior} / synechia nor any pupil deformity were observed. One patient had bilateral early optic atrophy with proliferative chorioretinitis consistent with ocular onchocerciasis. Although optic atrophy in its end stage may be uncharacteristic of any specific etiology, the presence of proliferative chorioretinitis makes the possibility of onchocerciasis a very likely cause for the optic atrophy. Only 3 patients had proliferative onchocercal chorioretinitis. The other 13 patients had a diffuse depigmentation at about the pigment epithelial level, some of which had a yellowish coloration at its base. These areas were not unlike drusen and certainly might be called drusen by some observers. These were located primarily in the posterior pole of the eye, and were more frequently seen in older individuals but were seen in one 24-year old. They appeared similar to what Dr. Ganley has observed in the savannah type of onchocerciasis. Although there was a high frequency of ocular onchocerciasis in Mawua, it was minimal in most. Most striking was the absence of even early sclerosing keratitis; the very few cases of proliferative chorioretinitis; absence of large patches of retina- and chorio-capillaris; and absence of a high frequency of optic neuritis and atrophy--all of which Dr. Ganley has observed in the savannah form of onchocerciasis.

III. J. Parasitologic Findings

1. Skin snips: At Barkaimai, only 6 (28%) of the 21 patients tested had microfilariae of O. volvulus in skin snips of one or both thighs (Table 1; Section III.A.3). Yet the other 15 patients with negative skin snips had nodules and/or other clinical manifestations of onchocerciasis. Even among those with positive skin snips, the mean total number of microfilariae in the 2 snips was very low ($\bar{x} = 8.1$ per 2 snips). This lack of correlation between a detectable microfilaridemia and clinical signs possibly could be explained by the promiscuous and irregular use of oral DEC ("banocide"). Discussions with patients at Barkaimai as well as with the staffs of Voinjama Hospital, Curran Lutheran Hospital/Zorzor and Konia Health Center revealed that banocide is readily available through a variety of sources in the Voinjama-Zorzor region--often taken for itching skin, without having had a skin snip test. Health posts such as the one at Barkaimai don't perform skin snips, but refer patients to a Health Center or Hospital for such tests; and those found to have positive snips are routinely given courses of banocide.

This contrasts with the results at the village of Luginyee, where 14 (93%) of the 15 tested had microfilariae in one or both thighs (Table 3; Section III.B.1). The sums for the two thighs went as high as 55-63 for patients No. 35 & 40 at Luginyee, compared to the maximum sum of 13 microfilariae per two snips for No. 12 at Barkaimai; and the mean microfilaridemia was 13.5 per 2 snips at Luginyee. In response to questioning, none of the patients at Luginyee admitted to having been treated with oral DEC. Likewise, the staff of LAMCO Hospital and the YMCA Clinic stated that banocide is not routinely dispensed in that

region of upper Nimba County, and that skin snips are not tested as frequently. (Frentzel-Beyme, 1975^a reported only a few hyperendemic villages in upper Nimba County along the Guinea and Ivory Coast borders-- Duopleh, Lugbeyee & Bonatown; villages #100-102. There was much lower microfiladermia in the rest of the County.)

2. Skin tests: The results of the intradermal tests with the exoantigens of cultured microfilariae, on the other hand, correlated closely with the occurrence of clinical manifestations in both villages, suggesting that this test may be significantly more sensitive than the skin snip method for diagnosing onchocerciasis. In Barkaimai, all but 2 of the 21 persons tested reacted positively--including Dr. Camanor, originally from the endemic region near Foya Kamara (Table 1; Section III.A.3). In Lugbeyee, all but 1 of the 15 patients tested reacted positively. (In 3 patients at these two villages, however, the reaction was relatively weak.) The reaction was typically characterized by the formation of a wheal ranging in size from 10 x 10 mm to 15 x 26 mm. The larger wheals often exhibited pseudopodia and they usually were surrounded by an erythematous zone. The reaction produced no apparent discomfort to the patient. The wheal appeared within about 15 minutes after injection of the microfilarial exoantigen; and regression of the wheal was complete in less than 2 hours. The saline control injections in the opposite (left) arms were negative in all cases. Histopathologic findings on biopsy specimens of the wheals are described in Section III.G.2.
3. Blood specimens: Blood was drawn from 19 of the 23 patients at Barkaimai; and from 15 of the 34 patients at Lugbeyee (Tables 1 & 3). Serum from these blood specimens has been separated, and will be used for pending immunochemical studies of onchocerciasis at the Johns Hopkins University by Dr. Schiller.

III. K. Entomologic Findings

1. Ecological settings for sibling species of *S. damnosum*: Section II.K.1 discusses physical characteristics of breeding sites for sibling species of the *S. damnosum* complex, as described by Garms and coworkers at the LRU-TIH. The team visited black fly sites #1 - 10 for these sibling species, as shown on Map 4 and Figs. 18 - 20. Sites #1 - 3 on the lower St. Paul River near Hendi as well as site #4 on the upper St. Paul River at Beyanstown (Fig. 18) are breeding sites of *S. sanctipauli*--characterized by a wide water course that lacks constant shade. Sites #5 - 9 are narrow and heavily shaded--characteristics of breeding sites of *S. yahense*: #5, Bene Creek at Konia; #6, Lawa River south of Barziwehn; #7, Lofa River at Barkaimai; #8, Baa River at Lugbeyee; #9, Yaa Creek near Zogowe (Fig. 19). Site #10 on the St. John River near Baila is wide and forested (Fig. 20); Garms & Vajime, 1975 found this to be a breeding site for *S. damnosum* (s.s.). Further details are to be found in that and other references by Garms, cited in Section II.K.1.

Based on the physical characteristics of the breeding sites for the sibling species described above, it seems likely that, if deemed necessary, aerial applications of larvicides could reduce populations of *S. sanctipauli* and *S. damnosum* (s.s.). This type of control however would not be completely effective for *S. yahense* nor for populations of *S. damnosum* occurring in irrigation systems. More careful applications of larvicides from the ground would be required to supplement a large scale aerial program. Any such program should use the larviciding technology developed by the WHO Onchocerciasis Control Program (WHO/OCP) in other West African countries.

III. K. 2. Xenodiagnostic assays: Black flies were caught after they had fed on the treated and untreated legs of selected patients, after one, two or three daily consecutive topical applications of DEC to the right leg. The number, motility and viability of microfilariae in the blood meal and thorax of such flies was then studied with a phase microscope. Comparison of the microfilariae from the treated and untreated leg then provided xenodiagnostic evaluations of the topical DEC treatment. These assays were conducted primarily with patients No. 12, 13 & 17 at Barkaimai, with the results given in Table 13. (Only a few black flies were caught with patients No. 31, 35 & 45 at Lugbeyee.) Even after three daily applications of topical DEC, the microfilarial load in the treated leg was not lowered to the expected infection threshold as reported by Langham et al, 1978. (No repellent effect of the Nivea Milk with or without DEC was demonstrated.) No striking differences were observed in the number, motor activity or morphology of microfilariae from the treated vs untreated legs (Table 13). The worms from the treated leg were fully capable of penetrating the gut and invading the thoracic musculature of the fly, the normal site of development to the stage infective for the human host.

The use of wild caught flies for xenodiagnosis proved to be more sensitive in detecting numbers of microfilariae than the conventional skin snip method (Table 1). Dissections of flies allowed to feed to repletion on DEC-treated and untreated legs indicated that the vast majority of flies was nulliparous and therefore posed no threat to the patient. However, until black flies can be routinely reared in the laboratory free of infectious agents, xenodiagnosis for onchocerciasis should be used with caution.

IV. DISCUSSION AND RECOMMENDATIONS--SUMMARY

Sections A, B & C of the Summary (pages i-iv) have reviewed the team's studies in Liberia, our experimental findings, and our recommendations for control of onchocerciasis in Liberia. Some additional, more detailed comments will now be presented.

The patients selected for ophthalmic examinations at Barkaimai and Lugbeyee were in no way representative of the total village populations. Many of the patients had been selected on the basis of nodules and other skin manifestations; and other were selected for reduced vision, especially in Lugbeyee. The best that one can get from this sample is an overall clinical impression of the manifestations and severity of the disease as it affects the eyes.

The eye is involved in the rain forest type of onchocerciasis but not to the same severity as in the savannah areas. This is true for all ocular forms of the disease: cornea, iris, chorioretina and optic nerve. The risk of severe blindness due to onchocerciasis is also proportionately lower in the forest region--approximately 1% as compared to 6-7% in certain endemic villages in savannah areas. The cause for this difference has been much discussed in the literature, but probably relates to the lesser density of human infection in the rain forest--although the prevalence of infection might be quite high. A number of authors have shown that severity of eye lesions both in savannah and forest regions is related to density of infection.

Our data generally substantiate the studies of Frentzel-Beyme 1973 & 1975b on the frequency of partial blindness in Liberia (acuity level of 6/60 or worse, comparable to legal blindness, i.e. 20/200 or worse in the United States), as well as the relative causes of blindness in Liberia. Frentzel-Beyme found a prevalence of 5.4% for partial blindness, 3.2% for economic blindness (3/60 or worse), and 1.4% virtual blindness (2/60 or less).

Our figure of 25% severe blindness (less than 1/60) among 48 inhabitants of Barkaimai & Lugbeyee (Table 9c) is highly skewed by the selective inclusion of known blind individuals from Lugbeyee. In a 1962 census, Lugbeyee had a known population of 741 individuals; we identified 6 villagers with severe bilateral blindness from our examination, for a crude estimate of 0.8%.

Frentzel-Beyme, 1975b broke down the causes of severe blindness as:

cataract, 45%; onchocerciasis, 25%; anterior segment, 14%; phthisis bulbi, 9%; and optic atrophy, 6%. Our comparable data for the villages of Barkaimai, Lugbeyee and Mawua combined is: cataract, 38%; glaucoma, 21%; onchocerciasis, 14%; cornea, 7%; trauma, 7%; and undetermined, 14%. Cataract, glaucoma and onchocerciasis are frequently causes of bilateral blindness; and frequent causes of unilateral blindness are bacterial and viral corneal infections, corneal foreign bodies, and traumatic injuries. Based on Dr. Ganley's discussions at Firestone, with Dr. Traub/and the staff of the Ophthalmology Clinic at J.F.K. Hospital, it would appear that along the coast of Liberia, measles keratitis is an important source of both unilateral and bilateral blindness. Measles keratitis is thought to occur in conjunction with low vitamin A levels; and the consumption of vitamin A-rich palm oil tends to protect against this disease.

Blindness in general appears to be of major economic importance in Liberia, and onchocerciasis causes a substantial portion of this disability--although considerably less than in the savannah areas of West Africa. The prevalence of legal blindness in the United States is approximately 150/100,000 population; the comparable figure for certain areas of Liberia is approximately 5400/100,000-- a 35-fold greater prevalence in Liberia than in the U.S. The portion of this blindness in Liberia due to onchocerciasis (25%) would give a prevalence for onchocercal blindness of approximately 1350/100,000--still 9-fold higher than the prevalence of all blindness in the U.S. Data would also suggest that people

blind from onchocerciasis have a shortened life span; and the experience from Liberia would suggest that individuals from a heavily infected area in general do not live as long as individuals from an area of low endemicity. The microfilariae in the skin almost certainly compete with host cells for the marginal protein and calories available in the diet.

Onchocerciasis and glaucoma may--and measles keratitis certainly appears to--affect younger individuals who still have a productive life ahead of them.

The economic loss is greater with these diseases than with cataracts, a disease predominantly of older individuals. Glaucoma is a treatable disease if detected early and provided adequate treatment. Measles keratitis may well be eradicated through the ongoing measles vaccination campaign. The periodic addition of ^{the diets of} vitamin A to/high risk children aged 6 months to 6 years, or general availability of vitamin A-rich palm oil to the diet, might also lower this complication. The cost benefit analysis of a campaign against onchocerciasis is dependent upon its relative morbidity compared to malaria, schistosomiasis, and measles as other controllable public health problems. The emphasis on any of these programs is dependent upon ease of control, cost of control, and efficiency of control balanced against overall morbidity. Certainly the removal of one disease from the country will reduce partially the parasitic burden from the human host and allow him to be that more productive.

The feasibility of a combined approach towards onchocerciasis eradication from Liberia appears to be very questionable at the present time. Larvicidal spraying in the rain forest terrain of Montserrado, Lofa, Bong and Nimba Counties, where the disease is prevalent, would be a Herculean task requiring men on foot to spray the smallest streams and rivers--shaded breeding sites of S. yahense (Section III.K.1). More success might be possible in controlling breeding sites of S. sanctipauli and S. damnosum (s.s.)--such as the St. Paul and

St. John Rivers--using the larviciding technology developed in savannah regions of other West African countries, by the World Health Organization/Onchocerciasis Control Program (WHO/OCP). This depends primarily on aerial spraying of such larger, less-shaded rivers. Any program of ground and aerial larviciding in Liberia would also need to be carried out in collaboration with the bordering countries of Sierra Leone, Guinea and Ivory Coast where the flies are also prevalent. The spraying would need to be carried out 3-4 times per year for at least 20 years--in the manner of the WHO/OCP. The cost of such a program would be financially unfeasible for the GOL alone, and would require massive assistance from the WHO/OCP, World Bank, and/or USAID, etc.

Chemotherapeutic control of onchocerciasis using systemic DEC and suramin have not been used for widespread campaigns, because of severe allergic reactions and morbidity. Nodulectomy has not been proven to lower either the microfilarial densities nor ocular complications. Topical applications of DEC--proposed by Langham et al, 1978 and independently tested by our team on a small scale at Barkaimai and Lugbeyee--probably has no major role to play in mass campaigns to control onchocerciasis in Liberia, and other countries. Nevertheless extensive, carefully controlled studies should probably be carried out to assess the efficacy of topical DEC. We understand that Langham, Traub and coworkers contemplate further trials of topical DEC at the Firestone Plantations in Montserrado County. Other areas where trials might be considered are the Voinjama & Zorzor districts of upper Lofa County, and upper Nimba County, where Frentzel-Beyme, 197a reported still higher prevalences of microfilarial carriers; carriers and nodule / and where our team carried out trials at Barkaimai and Lugbeyee. The health clinics of the Lofa County Rural Health Project could certainly assist with any trials jointly sponsored by GOL and USAID. But the

team wishes to emphasize again Recommendation No. 5 (in the Summary):

5. that limited and carefully controlled study of patients treated with topical DEC be done to determine the mechanism of action and efficacy; and that this study be planned and executed by a group of specialists including a clinician, pathologist, ophthalmologist, parasitologist, entomologist, epidemiologist and clinical pharmacologist. This study should be developed in cooperation with, or according to, the same protocols being used by the WHO/OCP, so that the results can be compared with the results of studies by WHO which, we understand, are now being undertaken in Ghana and Nigeria.

Any topical applications of DEC to the face should only be done with great caution, and under the supervision of an ophthalmologist equipped with a slit lamp (requiring a portable generator, unless electricity is available such as at some Health Centers or hospitals). This is important because the topical DEC could increase ocular morbidity by driving the microfilariae deeper into the tissues; and since the eye would have lower concentrations of DEC, the microfilariae may well migrate into the eye. A flare-up of chorioretinitis and development of optic neuritis has been observed following systemic DEC therapy, so that the ocular status would have to be carefully observed in any program of topical DEC therapy as well. The 2% DEC in Nivea Milk is definitely not something that should be widely dispensed to illiterate villagers, some of whom would be likely to apply the lotion haphazardly to their face!

Again, topical applications of DEC should be carefully supervised by appropriate medical personnel. Skin snips should be counted before and after treatment--preferably from the outer canthus as well from the thighs, hips or buttock, etc. Slit lamp examinations should be performed before and after treatment, to check for changes in numbers of microfilariae in the corneas or anterior chambers; punctate keratitis; chorioretinitis; optic neuritis or atrophy--and other symptoms of ocular onchocerciasis.

We have previously discussed the continuing studies of topical DEC by Drs. Langham, Traub and coworkers at Firestone Plantations in Montserrado County. In Bong, Lofa and Nimba Counties, the personnel are not as yet set up to carry out any mass campaigns with topical DEC. ^{Again} we recommend that no mass campaigns be considered until controlled studies are completed in more limited areas. The health care systems in these counties are organized primarily around health clinics (Health Posts & Centers) and a very limited number of hospitals with fully trained physicians. The health clinics appear to be predominantly maternal & child health clinics--serving pre- and post-natal mothers, younger children, etc. Only infrequently do they serve the rest of the adult population--especially the middle-aged harvesters who are more likely to be afflicted with onchocerciasis. Thus a program of topical DEC treatment centered at such health clinics would not reach the people most in need of such treatment, unless special efforts are taken. A more fruitful approach might be to utilize paramedical personnel of existing teams such as used in the schistosomiasis control program in some of the regions that are also hyperendemic for onchocerciasis (e.g. upper Lofa County). Such teams would require less training to carry out the topical DEC treatment. Bong County is developing a group of village health workers who might be utilized in such a program. In upper Nimba County many villages such as Lughbeyee are served by YMCA clinic workers, and visits when needed by the staff of LANCO Hospital. Such paramedical personnel might distribute and apply the topical DEC to villagers with a minimum cost, as well as take skin snips. Antihistamine and aspirin might also be needed, because of the reactive pruritus that can result from treatment with DEC.

Medical services are unevenly distributed throughout Liberia. There are a few hospitals in each county: J.F.K. Hospital, Monrovia and Firestone and

Elwa Hospitals in Montserrado County; Phebe and Bong Mine Hospitals in Bong Co.; Zorzor and Voinjama Hospitals in Lofa Co.; Ganta and LAMCO Hospitals in Nimba Co.; and some better equipped mission clinics such as that at the Pentecostal Mission in Foya Kamara, Lofa Co. But the health clinics provide primary service to most rural village--and then mainly for maternal and child health. Liberia's total population of approximately 1.6 million people is served by only 3 ophthalmologists: Dr. Traub at Firestone Medical Center; and Drs. Tudae-Torbah & Han at J.F.K. Hospital. Likewise there are only two pathologists to our knowledge: Dr. Brewer and his assistant Dr. Maale (?)--whom we didn't meet---at J.F.K. Hospital. The medical personnel at the concession and mission hospitals have only limited experience in many fields. The medical personnel within Liberia could certainly not provide the specialists called for in our Recommendation No. 5 (above), to supervise the trials of topical DEC. Consultants from the WHO/OCP, USAID, LRU-TIH, etc. would therefore be needed for such trials.

For long-term, mass chemotherapy programs (after completion of such trials), the distribution and application of the topical DEC would have to be taken into the villages. The campaign would have to be somewhat similar to those waged by the small pox irradiation program, measles vaccination programs, and the like. In the initial trials considerable experience would be needed to determine the efficacy and side effects of topical DEC, and to determine whether it lessens the microfilarial load, decreases ocular complications, and increases life expectancy of the villagers. But once side effects and safety aspects are determined, the mass campaign might eventually be carried out by Physician's Assistants and others with limited training. If roughly 15-20% of Liberia's population lives in endemic regions, then 250-300 thousand persons would need to be treated. We don't have any estimate for the cost of such a program of mass topical DEC treatment.

APPENDIX I. ITINERARY OF THE ONCHOCERCIASIS TEAM FOR LIBERIA

(Log book kept by Dr. Gibson, and supplemented by other team members)

Date & Time (All times are local)

Saturday,
25 Nov 78

1630(EST) Drs. Connor, Gibson & Schiller depart Kennedy Airport, NYC

Sunday,
26 Nov 78

0545(GMT) Arrival at Roberts International Airport, Harbel, Liberia. Met by Mr. Edward C. Anderson, Deputy Director, USAID Mission/Monrovia.

0700 Drs. Connor, Gibson & Schiller check into Robertsfield Hotel.

1330-1345 Drs. Connor & Gibson visit Liberian Institute of Biomedical Research, LIBR. Dr. Dennis, Director, is still in Europe, but due back 28 Nov. Talked with lab workers and saw chimp colony for Hepatitis B project.

1415-1500 Drs. Connor & Gibson visit Rev. Bradley Brown, Director, Liberian Baptist Seminary, near Elwa*. Rev. Brown directs Drs. Connor & Gibson to Dr. Young at Elwa Hospital, and mentions Dr. Oren & Mrs. Martha Robison, Baptist missionaries in Voinjama; Mrs. Robison provides community medical services.

1515-1630 Drs. Connor & Gibson visit residence of Dr. Frank Young, Director, Elwa Hospital; with Mrs. Young and house guests--Mr./Mrs. Gray Edward, of Firestone Plantation, Harbel. Dr. Young discusses medical services provided by his hospital of interest to Oncho. Team. Mr. Gray agrees to inform Drs. Jollah & Traub of Firestone Medical Center that Oncho. Team was in Liberia, and would try to visit them during the next week. Dr. Young described one patient at Elwa with a large necrotizing and undermined ulcer of the arm whose description suggested a mycobacterial ulcer--Buruli ulcer, caused by mycobacterium ulcerans--in which Dr. Connor has a research interest.

Monday,
27 Nov 78

0745-1120 Drs. Connor, Gibson & Schiller check out of Robertsfield Hotel, and transfer to Monrovia. Team checks into USAID house at 85 Coleman Ave., in Sinkor section of Monrovia.

1130-1200 Team is briefed at USAID Mission by Deputy Director Anderson and by Winifred Kpabar. Team fills out forms for extended visa (to 21 days).

1400-1430 Team is briefed at U.S. Embassy by Mr. Julius W. Walker, Deputy Chief of Mission. He discusses commitment of GOL to control and treatment of oncho. in Liberia, and discusses plans of Oncho. Team. Mr. Walker had talked earlier that day with Mr. H.J. Ashe of Bethlehem Steel, PA and LAMCO Mining Co., Yekepa--in Liberia for LAMCO Board meetings in

* Also Rev. Brown's wife & children: Lydia, Miriam & David. Dr. Gibson and Browns have a mutual friend, Dr. Jane Ann Moore, Councilmember, Montgomery Co., Maryland. Dr. Moore was Rev. Brown's thesis advisor at Howard University, Washington, D.C. Dr. Connor discovered he and Browns also have a mutual friend, Dr. Ross Green, former classmate of Dr. Connor, and occasional guest staff member at Elwa Hospital--who delivered David Brown.

(APPENDIX I)

Monrovia and Yekepa, during 27 Nov - 1 Dec. Dr. Gibson and Mr. Ashe had communicated by phone and letter in U.S.A., about possibility of visit of Oncho. Team to LAMCO Hospital, for studies of a nearby hyperendemic village such as Lugbeyee (see text Section II.F). Mr. Ashe relayed message through Mr. Walker to Dr. Gibson that LAMCO Hospital would welcome a visit by the Oncho. Team--during the second week, when LAMCO guest house should be available.

(27 Nov 78)

- 1445-1515 At Ministry of Health and Social Welfare, Oncho. Team meets the Deputy Minister, Mr. Robert Ellis, and is briefed by the Minister, Hon. Kate Bryant. She reconfirms interest of GOL in a treatment program for oncho. in Liberia, and conveys regrets that because of illness the Team could not meet that day with Mrs. Arabella Greaves, Asst. Minister for Research, Planning and Development.
- 1620-1640 Drs. Connor & Gibson visit John F. Kennedy Memorial Hospital, but find no professional staff available to meet them at the Eye Clinic, Dermatology Clinic, or Dept. of Pathology. They are escorted around J.F.K by a postal clerk.
- 1650 Dr. Connor cables Dr. Ganley in Arizona through USAID Mission that he still hadn't arranged for loan of a slit lamp from a Liberian ophthalmologist, so Dr. Ganley should probably bring a slit lamp and generator from U.S.A. (No luck at Eye Clinic, J.F.K; and phone lines not open to Dr. Traub at Firestone Medical Center.) Cable never received before Dr. Ganley departed Arizona, 4 Dec.

Tuesday,
28 Nov 78

- 0830-0930 Drs. Connor & Gibson revisit J.F.K Hospital, and meet with Dr. Tudae-Torbah, Ophthalmology Clinic; and with Dr. Rubell Brewer, Chief of Pathology Dept.; staff of Dermatology Clinic not available. They discuss eye diseases in Liberia, and possibilities for autopsies of persons from hyperendemic villages--even for deaths from other causes. J.F.K. pathologists go to local villages for medical legal autopsies, but rarely bring bodies to J.F.K. J.F.K however, is only hospital in Liberia with pathologists and adequate autopsy suite. (At Phebe Hosp. 1 Dec 78, Dr. Gwenigale gave team a tour of autopsy room--which had not been used for several years.)
- 0940 Drs. Connor & Gibson checked in briefly at USAID Mission, then left for Harbel.
- 1100-1225 Drs. Connor & Gibson arrive at Firestone Medical Center, but Dr. Traub was then at Harbel Clinic, where they consult with him for about an hour. They discuss topical DEC treatment of Langham & Traub (Sections I.D.3 & II.D.1), and proposed trials at selected villages by Oncho. Team. Eye studies by Dr. Ganley were also discussed, and Dr. Traub offered the use of a portable slit lamp and generator.
- 1240-1310 Stopped at Pan Am Cargo Dept., Roberts International Airport, to pick up empty container for Liquid Nitrogen--which Dr. Schiller had brought for proposed cryo-preserved tissues and flies. Container failed to arrive with team's flight on 26 Nov. (Subsequent efforts to obtain Liq. Nitrogen through USAID Mission were unsuccessful--though it is available with advance notice from Dakar, Senegal. Container was left with Dr. Dennis, LIBR, for future collaboration with Dr. Schiller.)

(APPENDIX I)

(28 Nov 78)

1700(GMT) Dr. Connor cables Dr. Ganley in Arizona that Dr. Traub will loan slit lamp and generator--so not to bother bringing such from U.S.A. But again the cable didn't reach Arizona before Dr. Ganley's departure.

1700(EST) Dr. Cupp departs Kennedy Airport, NYC.

Wednesday,
29 Nov 78

A Liberian Holiday--former President Tubman's birthday; all GOL offices, USAID Mission and LIBR are closed. Team therefore plans trip to LRU-TIH.

0815(GMT) Dr. Cupp arrives at Roberts International Airport, Harbel, Liberia; -1000 and proceeds to Monrovia, where he checks in at USAID Mission and USAID house. Rest of team is already on the way to LRU-TIH.

0815-0945 Drs. Connor, Gibson and Schiller travel to the Liberia Research Unit of the Tropical Institute Hamburg (LRU-TIH) at the Bong Iron Mine, about 50 miles northeast of Monrovia (Maps 1 & 5; Section II.C).

0945-1245 Team consults with Drs. Blüttner & Albiez, General Medical Officers at LRU-TIH who are studying onchocerciasis in Liberia. They brief team on their ongoing research and earlier work at LRU-TIH by Frentzel-Beyme, Garms and others (see text sections I.D.2 & II.C). Team tours facilities of LRU-TIH and discusses research of its staff on bancroftian filariasis in the vicinity of Foya Kamara, Lofa County (where Drs. Connor & Gibson visited Pentecostal Mission Clinic, 6 Dec). Team discussed possible collaboration with LRU-TIH staff on topical DEC treatment at a village in the vicinity of Bong Iron Mine, and toured a house which could serve as clinic for such studies (used by LRU-TIH for convalescence from oncho. nodulectomies). A tentative protocol for such studies was discussed.

1430-1630 After lunch at Blüttner residence, team was taken on a tour of 2 hyper-endemic villages (Hendi & Gaingaima) and nearby black fly breeding sites #1-3 on the St. Paul River (Maps 4 & 5; Sections II.C & II.K.1.a). Dr. Blüttner also gave specific information about other black fly sites in Bong, Lofa & Nimba Counties that had been studied by Garms & Vajime, 1975--some of which were later visited by team members (Map 4; II.K.1).

1645-1820 Drs. Connor, Gibson & Schiller return to Monrovia, joining Dr. Cupp at USAID house where he had arrived during the morning.

Thursday,
30 Nov 78

0920-1010 Team is briefed at USAID Mission by Deputy Director Anderson and by Mr. Jack Cornelius, Project Officer for USAID projects in upper Lofa Co.--based in Voinjama. Mr. Cornelius reviews rural development and health projects there, as well as smaller scale projects in Bong & Nimba Counties--some of which are under "Participating Agency Service Agreements" (PASA); or under "Partnerships for Productivity" (PFP).

1030-1100 Drs. Connor & Cupp meet with Mr. Perry Tennyson at his offices at J.F.K. Hospital (Tubman National Institute of Medical Arts, TNIMA). He is the USAID staff-member who handles logistics of rural health projects in upper Lofa Co., and makes arrangements for use of USAID guest house in Voinjama (where team later stayed 2-8 Dec). A tentative appointment is made for Dr. Connor to meet Dr. Mertens at TNIMA later in the day, when he is due back (see 1620-1730, below).

(APPENDIX I)

(30 Nov 78)

1245-1345 Team travels to Liberian Institute of Biomedical Research (LIBR), near Harbel (Map 1).

1400-1500 Team has its first briefing with Dr. Emmet Dennis, Director of LIBR-- and professional consultant to the team, under previous arrangements with USAID/Washington and APHA. He discusses oncho. in Liberia in relation to other parasitic diseases (including schistosomiasis research project of LIBR, based in Voinjama; and malaria research project of LIBR & LAMCO Hospital collaborators, based in Yekepa-- both of which were later visited). The team briefed Dr. Dennis on its proposals for studies of topical DEC treatment in selected villages of Lofa, Bong or Nimba Counties, and enquired about any arrangements he might have made. Dr. Dennis did not have a prearranged schedule for the team, but would let the team choose projects it thought would best help it fulfill its mission. He could not accompany team on field trips, because of upcoming dedication of LIBR on 12 Dec--which he invited the team to attend. He informed team that the Ministry of Health had agreed to provide a MOH driver, and Mr. Winston Clark, Div. of Communicable Disease/MOH was to join the field studies of the Oncho. Team. The USAID Mission had already arranged for a USAID driver; so it was tentatively decided that Drs. Connor, Cupp, Gibson and Schiller would proceed with USAID driver. The team hoped Dr. Ganley might arrive Sunday 3 Dec rather than 5 Dec. The tentative plan was for Mr. Clark & MOH driver to await arrival of Dr. Ganley in Monrovia, and the three of them to then join the team up-country (uncertain at that time whether this would be at Phebe Hospital or Voinjama Hospital). Things eventually did not go as planned, however. (Dr. Ganley arrived 5 Dec; MOH driver had an accident the day before he was to leave; Mr. Clark had car trouble on the road from Monrovia to Phebe Hospital, and so was unable to join the team at Voinjama; a second USAID driver took Dr. Ganley to Voinjama, 6 Dec.) Dr. Dennis also introduced team to Dr. Harold Prince of Columbia Univ. who has a collaborative research project on hepatitis at LIBR, including a chimpanzee colony used for in vivo transmission studies. (Dr. Gibson has a prior research interest in hepatitis.) See also Section II.B.

1510-1610 Team returns to Monrovia.

1620-1730 Drs. Connor & Gibson meet with Dr. Paul Mertens, USAID instructor of PA's & midwives at the Tubman National Institute of Medical Arts (TNIMA) at JFK. Dr. Mertens was very familiar with health services in upper Lofa Co.--having been in Liberia about 15 yrs.--previously serving as Medical Director of Curran Lutheran Hospital/Zorzor; and as USAID Chief of Party of Lofa Co. Rural Health Project, based at Voinjama Hospital. Dr. Mertens marked our geologic survey maps to show the Health Centers, Health Posts, and Hospitals in Lofa & Bong Counties. He expected to see that evening Dr. Gwenigale, Director of Phebe Hospital--who was coming for a meeting at MOH the next morning. Dr. Mertens offered to help facilitate arrangements for studies of team at Phebe Hospital and/or at Voinjama. He gave Drs. Connor & Gibson copies of proposals and progress reports on Lofa Co. Rural Health Project. See also Section II.A.2.e.

(APPENDIX I)

Friday,
1 Dec 78

- 0830-0930 Team has a briefing at USAID Mission with Dr. Mertens & Dr. Gwenigale, prior to latter's meeting at MOH. It is tentatively arranged that team will visit Phebe Hospital that night, to look into possibilities for studies of topical DEC treatment in villages in that vicinity--and also to go to Voinjama from there to check possibilities, before deciding where research studies would be based.
- 0945-1015 Dr. Mertens accompanies Drs. Connor & Gibson to MOH, where MOH radio operator makes contacts with staffs of Phebe Hospital and Voinjama Hospital--for tentative arrangements for team during following week.
- 1030-1200 Team buys supplies for field studies up-country, and packs for trip.
- 1200-1510 Team travels from Monrovia to Phebe Hospital near Suakoko, stopping enroute at "Cuckoo's Nest Hotel" near Totota (former President Tubman's Farm). Distance from Monrovia to Suakoko is about 120 miles (Map 1).
- 1515-1930 Team meets Mr. Stewart, General Manager of Phebe Hospital, and is taken to accommodations in Cottage #14 (Drs. Connor & Gibson) and Brown Hall #2 (Drs. Cupp & Schiller). Arrangements are made to meet with medical staff, after supper.
- 2000-2130 Team has a briefing with Dr. Aläppat F. David, soon joined by Dr. Gwenigale, who had just returned from Monrovia. Team discusses possibilities for studies of topical DEC treatment in selected villages, with team based at Phebe Hospital. Dr. Gwenigale suggests patients might be brought to convalescent quarters at Phebe Hospital. He expresses skepticism that farm workers in villages could take time out from harvesting for the proposed studies, or that "fly boys" would or should be allowed to be bitten by black flies for the proposed entomologic studies. At that time, the team expected to stay at Voinjama only the night of 2 Dec, then return to Phebe Hospital the night of 3 Dec. Drs. Gwenigale and David accordingly agreed to screen patients on the wards for patients with nodules, positive skin snips, and/or ocular onchocerciasis--for review by the team starting Monday, 4 Dec. (Team subsequently decided to base its studies at Voinjama, rather than return to Phebe Hospital; only Dr. Gibson returned the night of 3 Dec, to retrieve supplies left there by the team; ward round for team were cancelled.) See also Section II.D.2.

Saturday,
2 Dec 78

- 0730 Team departs Phebe Hospital for Voinjama.
- 0830-0900 Team stops at bridge over St. Paul River from Tolbert Farm (Bong Co.) to Beyanstown (Lofa Co.). This is black fly site #4 (Maps 1 & 4; Fig. 18), studied earlier by Garms & Vajime, 1975 as breeding site for Simulium sanctipauli (Sections II.C & II.K.1.a). However only a few flies were found at this visit, where team was at rocky beach on north shore of river (Lofa Co. side), on the upstream side of bridge. Team also met Chief Beyan of Beyanstown (= St. Paulsville), which is village #20 of Frentzel-Beyme, 1975, who reported very highly positive skin snips and oncho. nodules. It was considered high on list of villages to be studied, if/when team returned to a base at Phebe Hospital. The Chief's

(APPENDIX I)

(2 Dec 78)

14-year-old daughter is examined by Dr. Connor, who notes apparent punctate keratitis, believed due to onchocerciasis. (Dr. Gibson later stopped at Health Center at Tolbert Farm across the river, 4 Dec, and learned that the daughter had been tested there and found to have positive skin snips; and that she had been treated several times at J.F.K. On 8 Dec, while enroute to Yekepa, Dr. Ganley examined her with an ophthalmoscope and found her to have glaucoma; but he didn't have time to set up generator and slit lamp to look for microfilariae and other signs of ocular onchocerciasis.)

- 0930-1000 Team stops at two smaller creeks in lower Zorzor District of Lofa Co., hoping to find sites for S. yahense black flies; no larvae are seen.
- 1045-1145 Team stops enroute at Curran Lutheran Hospital, Zorzor, and visits with Dr. Erik Svenkerud, Medical Director, as well as his technician. Dr. Connor enquired about patient that Dr. Svenkerud had communicated with AFIP about (through ham radio operator): an ulcer in a body then at Curran Hosp., but subsequently moved to Pentecostal Clinic at Foya Kamara. Dr. Svenkerud suspected diphtheria, based on stains of a smear; but Dr. Connor doubted diphtheria, suspecting instead Buruli Ulcer or Tropical Phagedenic Ulcer. (This patient was subsequently examined and biopsied, 6 Dec, at Foya Kamara; histopathologic studies gave definitive diagnosis of Buruli Ulcer; see Section II.D.5). Dr. Svenkerud also discussed other diseases commonly seen at Curran Hospital; see also Section II.D.3.
- 1330-1440 Team stops enroute again at a Bene Creek, about 1/4 mile north of Konia--black fly site #5 (Maps 2 & 4; Section II.K.1.b). Many villagers bathe and wash clothes, and several black flies are caught there by Drs. Cupp & Schiller--who plan to return to this site on 3 Dec. Black flies at this creek were later dissected, and are believed to be S. yahense.
- 1530-1630 Team arrives in Voinjama, stopping first at residence of Gilda DeLuca, USAID nurse; and next at residence of Dr. George Berg, Chief of Party of USAID's Lofa Co. Rural Health Project, based at Voinjama Hospital. He took us to the USAID guest house on the main road from Zorzor, near the south edge of Voinjama. Dr. Berg said he would arrange a briefing with other medical staff of Voinjama Hospital--later that evening, at USAID guest house.
- 1900-2100 Team has extended briefing at USAID guest house with Dr. Berg, as well as Dr. Ramamoorthy, Lofa Co. Medical Director and Director of Voinjama Hosp.; and Dr. Ivan Camanor, a Liberian physician at the hospital (son of a Chief of Gissi Tribe at Foya Kamara). We discuss possibilities for studies of villages in the Voinjama District (rather than basing operations at Phebe Hospital--see 1 Dec). Studies near Foya Kamara (through Dr. Camanor) were decided to be unwise, because Kuhlow and coworkers at LRU-TIH had found bancroftian filariasis there as well as onchocerciasis. After reviewing results reported in Frenzel-Beyme, 1975^a for that district, the team decided on studies at the Health Post at Bakaimai (Section II.E). The Health Post could serve as a suitable facility for teams examinations and tests, and its staff could provide ^{river} liason with the Chief of the village. Location of the village on the Lofa_{river} was expected to provide a site for catching black flies for entomologic studies of Drs. Cupp & Schiller (site #7; Maps 2 & 4).

(APPENDIX I)

Sunday,
3 Dec 78

- 0815-1700 Drs. Cupp & Schiller spend the day catching black flies at Bene Creek, north of Konia (site #5; Maps 2 & 4; Section II.K.1.b). Several fly boys with clinical manifestations of onchocerciasis are paid, according to the number of flies caught. Black flies at site #5 are believed to be S. yahense:
- 0815-0930 Drs. Connor, Gibson & Camanor travel to Barkaimai (locally known as Barkeidu by Moslem population). They stop first at house of Mary Yallah, trained midwife at Health Post. James Nah, P.A., was away from village until 4 Dec. Mary Yallah had pruritus, and is selected as patient No. 1 (Tables 1 & 2). She acts as liason to outgoing Chief, Lansana Kanneh, who consents to the study, and welcomes team to Barkaimai. The Chief spreads the word for villagers to go to the Health Post for examination and screening for onchocerciasis.
- 0945-1330 Drs. Connor, Gibson & Camanor screen about 50 villagers, and select patients No. 1-14 for further study (Table 1). Patients are examined for nodules, dermatitis, lymphadenitis and other clinical manifestations of onchocerciasis. (Skin snips, etc. weren't done until 4-6 Dec, when Drs. Cupp & Schiller were present.)
- 1330-1700 Dr. Connor accompanies Mary Yallah and Drs. Berg & Camanor to nearby beach on Lofa River--site #7 (Maps 2 & 4; Section II.K.1.b)--thought to be breeding site of S. yahense; then all but Mrs. Yallah return to Voinjama.
- 1330 Dr. Gibson departs for Phebe Hospital.
- 1430 Dr. Gibson stops at Bene Creek near Konia, where Drs. Cupp & Schiller are catching black flies.
- 1615 Dr. Gibson stops at Beyanstown and talks with Chief Beyan (see 2 Dec, 0830-9000).
- 1715 Dr. Gibson arrives at Phebe Hospital, after stopping enroute for a tour of the campus of Cuttington College a few miles away.
- 2030 Dr. Gibson talks by phone with Dr. Gwenigale and explains the team's change of plans--for studies at Barkaimai, based at Voinjama, rather than studies at Beyanstown, with team based at Phebe Hospital.

Monday,
4 Dec 78
0915

- Dr. Gibson packs up team's remaining supplies to be taken to Voinjama, and consults with Dr. David at Phebe Hospital--to explain change of plans. (Dr. Gwenigale was not in his office.) Dr. David introduced Dr. Gibson to Mr. Benson, Bong Co. Health Inspector from Gbarnga--plus three assistants--who had come to Phebe Hospital expecting to take Drs. Cupp & Schiller on a tour of streams where black flies breed. Mr. Benson discussed spraying with insecticides such as DDT, Abate and malathion (?). A message was radioed from Phebe Hospital to MOH/Monrovia--to be relayed to USAID Mission--about/change of plans of team, for studies based at Voinjama rather than Phebe Hospital.
- 1010-1100 Dr. Gibson departs Phebe Hosp., going to Gbarnga to look for a pharmacy. Stores are all closed, and villagers line streets for arrival of President Tolbert for dedication of new water tower near Gbarnga. Military guards try to prevent us from passing parade grounds and leaving Gbarnga; but USAID driver manages to get by the blockade--explaining the Oncho. Team's studies at the invitation of the GOL.

(APPENDIX I)

(4 Dec 78)

- 1145-1200 Dr. Gibson stops at Health Center at President Tolbert's Farm, and talks with PA--Capt. Joseph L. Johnson, Medical Officer, MSC--plus a midwife and technician. Capt. Johnson mentions that skin snips are regularly counted for microfilaria of O. volvulus; and in particular, skin snips from Chief Beyan's daughter have been positive in the past (see 2 Dec, 0830-0900). Dr. Gibson mentions possibility that Dr. Ganley might stop later in week to examine her eyes. Health Center has electricity, if needed for slit lamp. (She was examined by hand ophthalmoscope on 8 Dec, 1230-1245; there wasn't time for slit lamp examination.)
- 1345-1420 Dr. Gibson stops at Konia Health Center, and talks with Daniel Dalton, PA, Ester Cole, midwife, and technicians. This health center also ~~routinely~~ counts skin snips routinely and has a microscope. There is no electricity. Konia Health Center is considered a prospective place for further clinical studies, especially in view of the fact that Drs. Cupp & Schiller have caught hundreds of black flies from villagers of Konia at site #5, Bene Creek (Maps 2 & 4; Sections II.D.6 & II.K.1.b). (The team stopped at Konia Health Center on 8 Dec, 1135-1145, but didn't have time for clinical studies there.)
- 1515 Dr. Gibson arrives at Barkaimai Health Post, rejoining rest of team.
- ca. 0900 Drs. Connor, Cupp & Schiller spend the day at Barkaimai Health Post.
-1645 Many more villagers are screened, and the four new patients No. 15-18 selected for further study. (No. 18 is non-oncho. patient with penile lesion that turned out to be a squamous cell carcinoma upon histopathologic study of biopsy specimen.) Skin snips are counted, blood is drawn, and skin tests with microfilarial exoantigen are performed on most of the patients No. 1-17 (Table 1). Some patients are given the first topical application of DEC to the right leg (Table 2).
- 1645-1730 Team returns to USAID house/Voinjama.
- 1930-2100 Dr. Berg stops twice at USAID house to discuss team's studies at Barkaimai, and possible trip to LAMCO Hospital/Yekepa around the end of the week. He suggests sending a message to Dr. Sirleaf, Chief Medical Officer there.
- 2000-2200 Drs. Cupp & Schiller recount microfilariae in skin snips of patients
(GMT) No. 1-17 taken about 9 hours earlier. Snips are then transferred from water or saline into formalin, for histopathologic study (Section II.H.2).
- ca.
1700(EST) Dr. Ganley departs Kennedy Airport, NYC.

Tuesday,
5 Dec 78

- ca.0815-1030(GMT) Dr. Ganley arrives at Roberts International Airport, Harbel. He receives memo from Dr. Connor relayed through USAID Mission that suggests he try to meet Dr. Traub as soon as he arrives. But Dr. Ganley is unable to locate Dr. Traub and proceeds to Monrovia to check in at USAID Mission and USAID house. (He has various briefings later in the day.)
- 0700-0900. At USAID guest house/Voinjama, Dr. Gibson writes a letter to Dr. Sirleaf of LAMCO Hospital about team's plans to arrive in Yekepa, late in the afternoon of 8 Dec. Letter is carried by a Peace Corpsman by plane to Monrovia, where it is put in LAMCO mail bag for airmail to Yekepa.

(APPENDIX I)

(5 Dec 78)

- 1005-1050 Drs. Connor, Cupp, Gibson & Schiller go from Voinjama to Barkaimai.
- 1100-1530 Team sets up at Barkaimai Health Post and examines several more villagers, selecting five new oncho. patients No. 19-23 (Table 1). Patients No. 1-18 from 3-4 Dec are re-examined. Biopsy specimens are taken from patients given the first topical application of DEC on 4 Dec (Table 2). They are given a second application, and other patients are given the first application of topical DEC, topical Mintezol, or control Nivea Milk. Patient No. 23 is given first course of oral DEC. More skin snips, blood drawing and skin tests by Drs. Schiller & Cupp.
- 1615-1745 Team goes with patients No. 2, 9, 12, 13, 17 & 20 to Lofa River near the village of Barkaimai (site #7; Maps 2 & 4). About 10-20 black flies were caught from most patients, after flies had fed on the treated or untreated legs. It was noted that moist lotion on treated legs seemed to inhibit biting; so it was planned that in future, flies would be caught before a new application of lotion on a given day. Dr. Connor photographed flies biting his hand.
- 1745-1830 Team returns from Barkaimai to the USAID guest house at Voinjama.
- 1900-2030 Dr. Berg comes to USAID guest house to demonstrate how to use emergency generator there. (Voinjama's public power had failed a few times during the day, but was now working again.) Dr. Camanor also stops by later. Team's studies at Barkaimai are discussed, as well as proposed trip on 6 Dec by Drs. Connor & Gibson; Dr. Camanor hoped to accompany them.
- 2030-2200 Drs. Cupp & Schiller recount some skin snips taken earlier in day, and feed and/or dissect black flies caught earlier at Barkaimai or Konia.

Wednesday,
6 Dec 78

- 0845-0930 Team goes from Voinjama to Barkaimai.
- 0945-1245 Drs. Connor & Gibson set up at Barkaimai Health Post and examine patients treated 4 & 5 Dec, taking biopsies on some of them (Table 2). Patients are given second or third applications of topical DEC. Patients No. 16, 21 & 23 are given oral DEC (second daily dose for No. 23). During this time Drs. Cupp & Schiller catch flies fed on patients No. 12, 13 & 17 at Lofa River (site #7), following which patients are given their next applications of DEC lotion at the Health Post.
- 1245-1330 Team returns to USAID guest house, Voinjama.
- 1330-2000 Drs. Cupp & Schiller spend the afternoon and evening dissecting black flies caught 5-6 Dec at Lofa River, from treated and untreated legs--using dissecting microscope to count microfilariae and check their viability, for xenodiagnosis (Sections II.K.3 & III.K.4).
- 1400-1520 Drs. Connor & Gibson travel from USAID house, Voinjama to Foya Kamara. Dr. Camanor had to stay for a visit by MOH officials, and couldn't go as he had earlier planned.
- 1520-1800 Drs. Connor & Gibson meet with Irene Ståhlberg, head nurse, and her staff of three other nurses at the Swedish Pentecostal Mission Clinic at Foya Kamara (Section II.D.5). They examine the boy with healed ucler of the upper arm and acute ulcer of the foot--who had been a patient at Curran Lutheran Hospital previously, and who was discussed by Dr. Svenkerud there (see 2 Dec, 1045-1145). Ms. Ståhlberg also presented another boy with an

(APPENDIX I)

(6 Dec 78)

ulcer of the knee--suspected by Dr. Connor to be a buruli ulcer. The first boy was thought to have either a tropical phagedenic ulcer or a buruli ulcer. Biopsy specimens were taken of acute ulcers on both boys, who are patients No. 26 & 25 respectively (Tables 1 & 2). Subsequent microscopic study at AFIP revealed acid fast mycobacteria in both ulcers (Mycobacterium ulcerans)--allowing a diagnosis of buruli ulcer for both. Drs. Connor & Gibson and the clinic staff also discuss onchocerciasis, bancroftian filariasis and other medical problems common in the region of Foya Kamara.

- 1800-1900 Drs. Connor & Gibson leave clinic, and visit village of Foya Kamara.
1900-2030 Drs. Connor & Gibson return from Foya Kamara to USAID house, Voinjama.
0900-1100 Dr. Ganley has meetings at USAID Mission, in preparation for trip to Voinjama to join team.
1100-1800 Dr. Ganley travels from Monrovia to Voinjama to join rest of team. (He goes with USAID driver, since MOH driver and Mr. Clark of MOH can't go-- see discussion under 30 Nov, 1400-1500.) Dr. Ganley didn't stop at Phebe Hospital, Beyanstown, or Konia Health Center because he hadn't received Dr. Gibson's radio message from Phebe Hospital on 4 Dec.

Thursday,
7 Dec 78

- 0900-0945 Team travels from Voinjama to Barkaimai Health Post.
1000-1815 Team sets up at Health Post. Drs. Connor & Gibson examine patients treated 4-6 Dec with topical or oral DEC, and take biopsy specimens of several lesions (Table 2). In particular, patient No. 16 had severe periorbital edema following oral DEC the previous day--and was subsequently found by Dr. Ganley to have numerous microfilariae and punctate opacities in the corneas and other manifestations of ocular onchocerciasis. A biopsy specimen was taken of her canthus. (See Tables 2 & 5). Dr. Ganley gave ophthalmic examinations with slit lamp powered by portable generator, to 16 patients among Nos. 1-23 studied by the rest of the team, plus other villagers with reduced vision (Table 5; Section II.I.1). Drs. Cupp and Schiller performed a few skin tests, blood drawings, skin snips etc. from patients missed previous days--plus skin test and blood on Dr. Camanor who arrived during the lunch hour (patient No. 24, Table 1). Before lunch and after lunch until 1400, Drs. Cupp & Schiller catch flies at Lofa River (site #7)--fed on treated and untreated legs of patients No. 12, 13 & 17.
1400-1445 Drs. Cupp & Schiller return with Drs. Berg & Camanor to Voinjama.
1815-1700 Drs. Connor, Ganley & Gibson return to Voinjama guest house.
1500-1600 Drs. Schiller, Berg & Camanor meet with Mr. Thomas N. Brima, Superintendent of Lofa County--at the Ministry of Local Government, Dept.(?) of Rural Development and Urban Reconstruction. A reporter is also present. Dr. Schiller explains the problems of onchocerciasis to the superintendent, and discusses the studies of the team at Barkaimai. The Superintendent was very interested in this project, and felt that it fits with a Liberian motto: "Deeds, not Words"; the team is in Liberia to prove the U.S. commitment to help Liberia with problems of oncho. by "deeds", following President Carter's commitment by "words" to President Tolbert, last spring--was the idea expressed by the Superintendent.

(APPENDIX I)

(7 Dec 78)

- 1500-1630 Dr. Cupp dissects black flies from studies at Lofa River, Barkaimai.
1630-2400 Drs. Cupp & Schiller continue to dissect black flies and examine blood meal, thoracic muscles, etc. of flies for microfilariae of O. volvulus--xenodiagnostic assays (Section II.K.3); this continues past midnight, since they need to complete it before team departs next morning for Yekepa; they finished at 0215, 8 Dec.

Friday,
8 Dec 78

- 0800-0945 Team packs supplies, in preparation for departing Voinjama for Yekepa.
0900-1000 Dr. Schiller visits the LIBR Schistosomiasis Lab in Voinjama.
0950-1015 Team is visited at USAID guest house by Dr. Mertens of USAID & TNIMA, Monrovia; Dr. Marshall, Chief of Pediatrics at J.F.K. Hospital; and Ms. Barbara Oolman, a 4th year medical student at Univ. of Iowa. They have come from Monrovia for a meeting in Voinjama.
1040 Team departs USAID guest house, Voinjama for LAMCO/Yekepa.
1135-1145 Team stops at Konia Health Center, and talks with Daniel Dalton, PA and staff (follow-up to Dr. Gibson's visit of 4 Dec, 1345-1420). He mentions that there are about 12 staff members at the Health Center; and that patients found to have positive skin snips are routinely treated with oral DEC over a period of several weeks.
1230-1245 Team stops at Beyanstown, and Dr. Ganley checks the eyes of the daughter of Chief Beyan (follow-ups to previous visits on 2 Dec, 0830-0900 and 3 Dec, 1615).
1245-1255 Team stops at Health Center at President Tolbert's Farm and talks with midwife; the PA, Capt. Johnson is away in Monrovia (follow-up of Dr. Gibson's visit on 4 Dec, 1145-1200). Drs. Ganley & Gibson also talk with a MAJ Kinney, Commandant at the President's Farm.
1545-1605 Team stops at Ganta United Methodist Hospital, and talks with Dr. Ring Decima, a G.P.--in the absence of Dr. Walter Stephenson, Ch. Med. Officer.
1730-2130 Team arrives at LAMCO/Yekepa, and checks into LAMCO guest house. Attempts to contact Dr. Sirleaf by phone were unsuccessful. Team meets with Dr. Michael Wilcox, a Research Officer at LAMCO Hospital for several weeks to work on the LIBR Malaria project in Nimba Co. He is joined later by Dr. Anders Björkman, Research Officer at LAMCO Hospital (whose home base is the Karolinska Institute, Stockholm)--also working on the LIBR Malaria project. Drs. Björkman & Wilcox are familiar with Luginbue village and the YMCA Clinic there--though it is not a village included in their malaria surveillance program. They offered to facilitate our studies at Luginbue--selected because it is hyperendemic for oncho., by reports in Frenzel-Beyme, 1975a (Sections I.D.2; II.C; II.F). They contact Mr. Orwar Alnesið, regional YMCA Director--who however will be unable to accompany team to Luginbue on 9 Dec, where YMCA pavilion is to be used. Therefore Dr. Björkman agrees to make contact with the Chief of Luginbue on 9 Dec.

(APPENDIX I)

Saturday,
9 Dec 78

- 0830-0900 Team consults with Dr. Warsay Sirleaf, Chief Medical Officer of LAMCO Hospital, discussing our proposed studies at Lugbeyee. He arranges to loan us two folding tables and a folding chair, for use at the YMCA pavilion clinic; and for a LAMCO employee to serve as translator-- Peter Komah.
- 0830-0900 Drs. Björkman & Wilcox precede team to Lugbeyee, and make contact with the Chief about the team's plans for studies there.
- 0915-1000 Team travels from Yekepa to Lugbeyee, and consults with the Chief, Quoi Duo, through translator Peter Komah.
- 1000-1200 Dr. Ganley goes door to door in village of Lugbeyee, giving preliminary eye tests to villagers with reduced vision--asking them to come to school master's house next to YMCA pavilion in the afternoon, for ophthalmic examination with slit lamp.
- 1000-1600 Rest of team sets up in YMCA pavilion clinic, and screens about 25 adults for nodules and other signs of oncho.; skin snips are counted, blood drawn, and skin tests performed on 15 villagers, patients No. 31-45 (Fig. 1; Table 3; Section IIF). Patients also given first application of topical DEC (Table 4).
- 1200-1600 Dr. Ganley sets up slit lamp in room of school master's house, next to YMCA pavilion--performing ophthalmic examinations on some villagers with reduced vision he surveyed in door to door survey, plus some patients screened by rest of the team (Table 6).
- 1610-1700 Team travels from Lugbeyee back to LAMCO guest house.

Sunday,
10 Dec 78

- 0815-0855 Team travels from Yekepa to Lugbeyee.
- 0900-0915 At the suggestion of the Chief, the Team sets up at Lugbeyee Public School, just across a creek from the village--rather than at the YMCA pavilion in the village, used 9 Dec. Dr. Ganley uses one classroom for ophthalmic examinations, and Drs. Connor, Cupp, Gibson & Schiller use another classroom for examinations, biopsies and treatment. The school provides more privacy and better bench space than the YMCA pavilion. The team misses the help of the staff of a Health Post or Center, such as we had at the Barkaimai Health Post.
- 0915-1640 Drs. Connor & Gibson examine patients No. 31-45, about 24 hours after their first topical application of DEC; and 7 patients receive a second topical application (Table 4). About 30 additional villagers are screened by the team, and 20 selected for further studies (patients No. 46-65). Of these, 16 receive intradermal injections of 25 mg DEC; others received no treatment or oral DEC (Tables 3 & 4). During the day, Drs. Cupp & Schiller go with patients No. 31, 35 & 45 to site #8 on Baa River, but they have little success catching flies there. Dr. Ganley gives ophthalmic examinations to more of the patients screened by the rest of the team, and others with reduced vision (Table 8). Biopsy specimens are taken from some of the patients (Table 4).
- 1700-1749 Team travels from Lugbeyee back to Yekepa--LAMCO guest house.

(APPENDIX I)

(10 Dec 78)

2000-2200 Drs. Cupp & Schiller go to the lab at LAMCO Hospital with Dr. Björkman, to dissect black flies caught at Lugbeyee and count microfilariae in bloodmeals and musculature--xenodiagnostic assays of Section II.K.3.

Monday,
11 Dec 78

- 0820-0850 Drs. Connor, Ganley & Gibson travel from Yekepa to Lugbeyee.
- 0900-1130 Team sets up at public school, in same rooms as for 10 Dec. Drs. Connor & Gibson examine patients No. 31-65, about 48 hours after first topical application of DEC, or 24 hours after intradermal DEC (Table 4). Several biopsy specimens are taken, but no further treatment, since this is the last day. Dr. Ganley finishes with ophthalmic examinations on all patients who showed up (Table 6).
- 1130-1200 Presentation ceremonies at YMCA pavilion by Chief to team; the Chief expresses the appreciation of the villagers of Lugbeyee for our studies of a major problem for them.
- 1200-1245 Drs. Connor, Ganley & Gibson return from Lugbeyee to LAMCO guest house.
- 0830-1300 Drs. Cupp & Schiller accompany Drs. Björkman & Wilcox who are going to villages south of the Nimba Range for their Malaria project. They visit black fly site #9 on Yaa Creek (Maps 3 & 4). The sibling species Simulium yahense was named after Yaa Creek by Garms & coworkers at LRU-TIH (text Sections I.D.2 & II.C) The terrain on the south side of the Nimba range, towards the border with Ivory Coast, looked more like savanna than any other area of Liberia that Dr. Cupp had seen.
- 1430-1500 Team checks out of LAMCO guest house.
- 1515-1545 Team consults with Dr. Sirleaf about results of our studies at Lugbeyee. Dr. Sirleaf suggests that the team's time in Liberia was too short to answer the questions about the severity of onchocerciasis in Liberia, and the effectiveness of topical DEC treatment.
- 1600 Team departs from LAMCO Hospital/Yekepa, for Monrovia.
- 1745-1755 Team stops enroute at bridge over the St. John River, to view site #10 where Garms & Vajime had found S. damnosum (s.s.)--Map #4 and Sections I.D.3 & II.K.1.c.
- 1840-1855 Team stops enroute at Phebe Hospital/Suakoko, where Dr. Ganley meets Dr. Gwenigale for the first time, and also a medical student from University of Arizona who is working there for a few months.
- 2000-2100 Team stops for supper at Cuckoo Nest Hotel, Tatato.
- 2300 Team arrives back at the USAID house, Monrovia.

Tuesday,
12 Dec 78

- 0800-1200 Team members begin organizing their sections of preliminary draft report, at USAID house. Drs. Schiller & Gibson go to downtown Monrovia, to reconfirm reservations at Pan Am and to get exit visas at Immigration Office.
- 1200-1300 Drs. Connor & Ganley visit J.F.K. Hospital, and meet with Dr. Nehemiah Cooper Chief of Medical Services at the Hospital--and discuss the team's results and recommendations for further treatment/control of onchocerciasis.

(APPENDIX I)

(12 Dec 78)

- 1530-1615 Team travels to LIBR, near Harbel.
- 1615-1700 Team meets with Dr. Dennis in Library of LIBR, and discusses results of team's studies at Barkaimai and Lugbeyee. Team is also introduced to Rev. Samford Dennis, father of Dr. Emmet Dennis.
- 1700-1815 Team attends dedication ceremonies for LIBR: Invocation by Rev. Dennis; Introduction speech by Dr. Emmet Dennis, Director, LIBR; Remarks and Dedication by Vice-President Warner; Presentation Speech by President Tolbert, read by Hon. Kate Bryant, Minister of Health and Social Welfare, and Chairman of the Board of Governors, LIBR.
- 1815-2000 Team tours facilities of LIBR, and has light refreshments. Team meets again with Drs. Björkman & Wilcox from LIBR malaria project at LAMCO Hospital, Yekepa. Team meets other staff members of LIBR, including Dr. ^(?)Refus van den Ende--Dutch researcher in LIBR Hepatitis Project, who is also interested in in vitro cultivation of microfilariae of O. volvulus (Dr. Schiller has experience with such cultivation).
- 2000-2100 Team travels back to USAID house, Monrovia.

Wednesday,
13 Dec 78

- 0800-1000 Team works on preliminary draft report, at USAID house.
- 1000-1230 Team has a conference at Ministry of Health, with Dr. Swamy, Director of Bureau of Preventive Services; Dr. Holder, WHO Coordinator; Dr. Dennis, LIBR; Mr. Clark, Div. of Communicable Diseases; Mr. Marsh & Mr. Hagel, USAID/Monrovia; Dr. van den Ende, LIBR; Drs. Büttner & Albiez, LRU-TIH (Section II.M).
- 1230-1330 Dr. Ganley meets further with Drs. Büttner & Albiez, concerning proposed ophthalmic examinations at Mawua in collaboration with the staff of LRU-TIH, 14-18 Dec (Sections II.I.3 & III.I.3).
- 1430-1600 Dr. Ganley meets with Dr. Tudae-Torbah and Dr. Han at the Ophthalmology Clinic at J.F.K. Hospital, to discuss onchocerciasis and other causes of reduced vision at their clinic (Section II.A.2.d).
- 1300-1700 Rest of team works on preliminary draft report, at USAID house--with secretarial assistance from USAID Mission.
- 1830-2300 Team works on preliminary draft report, at USAID house.

Thursday,
14 Dec 78

- 0800-1630 Team works on preliminary draft report, at USAID house as well as at the USAID Mission. Draft report is submitted to Deputy Director Anderson at 1630, for limited distribution.
- 0900-1100 Dr. Ganley makes ward rounds and sees patients in out-patient clinic at J.F.K Hospital, and talks with Dr. van Reken, staff pediatrician.
- 1630-1800 Dr. Ganley travels from USAID Mission, Monrovia to the LRU-TIH at the Bong Iron Mine, and is met by Dr. Büttner and Albiez.

(APPENDIX I)

(14 Dec 78)

- 1900-2015 Drs. Ganley, Büttner & Albiez travels to village of Mawua, about 11 miles by road from LRU-TIH (Map 5; Section II.I.3); they meet with the village chief and the town chief, and hold palaver with village inhabitants to arrange for study to begin the next day.
- 2015-2030 Drs. Ganley, Büttner & Albiez return from Mawua to LRU-TIH.
- 1700-2030 Drs. Connor, Cupp, Gibson & Schiller go to USAID house, and pack up supplies to depart Monrovia.
- 2030-2200 Drs. Connor, Cupp, Gibson & Schiller travel from USAID house/Monrovia to Roberts International Airport, Harbel; and check through customs and check-in, etc.

Friday,
15 Dec 78

- 0030(GMT) Drs. Connor, Cupp, Gibson & Schiller depart Roberts International Airport on Pan Am Flight #191.
- 0530(EST) Arrival at Kennedy Airport, NYC; check through customs, etc.
- 0610(GMT) Drs. Ganley, Albiez, Ehrenberg & Stierle meet at LRU-TIH and travel
-0630 to Mawua.
- 0700-1745 Dr. Ganley and collaborators set up slit lamp and other equipment; they perform canthal skin snips and ophthalmic examinations: visual acuity, anterior segment biomicroscopy, and dilated funduscopy; 25 patients are examined (Section II.I.3).
- 1745-1815 Dr. Ganley and collaborators travel from Mawua to LRU-TIH, and discuss results of first day's survey with Dr. Büttner.

Saturday,
16 Dec 78

- 0610-0630 Drs. Ganley, Ehrenberg & Stierle meet and travel to Mawua.
- 0630-1600 Dr. Ganley & collaborators examine 20 villagers; skin snips are not done, since that was felt to be an impediment to participation of villagers. Topical application of DEC in Nivea Milk, or control Nivea Milk along, was ^{given to faces of} performed on four villagers, based upon canthal skin counts and eye lesions.
- 1600-1630 Trip back to LRU-TIH.

Sunday,
17 Dec 78

- 0610-0630 Drs. Ganley, Ehrenberg & Stierle meet and travel to Mawua.
- 0630-1545 Drs. Ganley & collaborators examine an additional 20 villagers. Topical application of DEC is given to the same faces of villagers.
- 1730-1900 Drs. Ganley & collaborators discuss further results with Dr. Büttner.

(APPENDIX I)

Monday,
18 Dec 78

- 0610-0630 Drs. Ganley, Albiez & Ehrenberg meet and drive to Mawua.
- 0630-1000 Drs. Ganley & collaborators take canthal skin snips and perform anterior segment biomicroscopy on three of the four individuals to whom topical DEC was applied. Ophthalmic examinations are given to an additional 6 villagers.
- 1000-1030 Trip back to LRU-TIH.
- 1100-1200 Dr. Ganley travels from LRU-TIH/Bong Mine to Firestone Medical Center.
- 1210-1230 Dr. Ganley meets with Dr. Traub, ophthalmologist at Firestone Med. Ctr. and disucsses causes of blindness in Liberia; the magnitude of onchocerciasis problems; and preliminary results of treatment with topical DEC (Section II.D.1).
- 1230-1330 Dr. Ganley returns to USAID Mission, Monrovia and receives a copy of the preliminary draft report.
- 1600-1630 Dr. Ganley meets with Dr. Theodore Lefton, physician attached to the U.S. Embassy/Monrovia; they discuss the team's preliminary findings.
- 1700-2045 Dr. Ganley packs at USAID house, to depart Monrovia.
- 2045-2200 Dr. Ganley travels from USAID house to Roberts International Airport, and checks in.
- 2345(GMT) Dr. Ganley departs Roberts International Airport.

Tuesday,
19 Dec 78

- ca. 0800 Dr. Ganley arrives at Kennedy Airport, NYC
(EST)

APPENDIX II. CONTACTS IN LIBERIA
(including addresses when known)

A. U.S. Embassy, Monrovia:

Honorable Julius Walker, Deputy Chief of Mission

Dr. Theodore Lefton, Embassy Physician

B. USAID Mission, Monrovia (P.O. Box 1445):

Mr. Edward E. Anderson, Jr., Deputy Director

Mr. Noel Marsh, Senior Program Officer

Mr. Fred Hagel, Program Officer

Mr. Jack Cornelius, Project Officer, Lofa County Rural Health Project

Dr. Paul Mertens, USAID Instructor at TNIMA (see #I)

Mr. Perry Tennyson, USAID Project Officer at TNIMA (see #I)

Mr. Louis(?) Correa, Chief General Service Officer

Ms. Winifred Kpabar, Staff Aide

Mr. Philip Khan, Driver

Mr. David Attia, Driver

C. USAID Lofa County Rural Health Project, Voinjama (P.O. Box 1445, Monrovia):

Dr. George M. Berg, Chief of Party

Ms. Gilda DeLuca, Nurse

D. Medical Service Consultants, Inc. (P.O. Box 1445, Monrovia):

Mr. John Cipolla, Chief of Party

E. Indian Health Service

Dr. Michael Fuchs, Special Projects Officer; Consultant on Lofa County
Rural Health Project (home office: 50 United Nations
Plaza, Room 360, San Francisco, CA 94102)

(APPENDIX II)

F. Ministry of Health and Social Welfare, Monrovia:

Honorable Kate Bryant, Minister

Honorable Robert Ellis, Deputy Minister

Dr. M. Swamy, Director, Bureau of Preventive Services (P.O. Box 1812)

Dr. Wilhelmina V. Holder, WHO Coordinator

Mr. Winston Clark, Division of Communicable Diseases

G. Liberian Institute of Biomedical Research (LIBR), near Harbel:

Dr. Emmet A. Dennis, Director (P.O. Box 31, Robertsfield)

Dr. Harold Prince, Researcher, LIBR Hepatitis Project
(Professor at Columbia University)

Dr. Rinus (?) Van den Ende, Researcher, LIBR Hepatitis Project
(from Holland)

H. John F. Kennedy Medical Center (J.F.K. Hospital), Monrovia:

Dr. Nehemia Cooper, Chief of Medical Services

Dr. Rubell Brewer, Chief of Pathology (P.O. Box 1973)

Dr. Tudae-Torbah, Chief of Ophthalmology Clinic (P.O. Box 2588)

Dr. Han, Ophthalmology Clinic

Dr. Marshall, Chief of Pediatrics

Dr. David Van Reken, Pediatrics

Mr. Sunnie Macar, mailroom attendant (P.O. Box 1973)

I. Tubman National Institute of Medical Arts (TNIMA), Monrovia:

Dr. Paul Mertens, USAID Instructor (see #B)

Mr. Perry Tennyson, USAID Coordinator of USPHS Health Projects (see #B)

J. Elwa Hospital, Elwa:

Dr. Frank Young, Medical Director (P.O. Box 99, Monrovia)

K. Liberian Baptist Seminary, Elwa:

Rev. Bradley Brown, Director (P.O. Box 1778, Monrovia)

L. Liberian Research Unit of the Tropical Institute Hamburg, at Bong Iron Mine
(P.O. Box 538, Monrovia):

Dr. Dietrich Büttner, General Medical Officer

Dr. Eberhard-Johannes Albiez, General Medical Officer

Dr. John Ehrenberg, General Medical Officer

Dr. Mathias Stierle, General Medical Officer

M. Firestone Plantation, Harbel:

Dr. Zolu-Dumah, Ophthalmologist, Firestone Medical Center

Mr. Gray Edward, Executive, Firestone Plantation

N. Phebe Hospital, Suakoko (P.O. Box 1046, Monrovia):

Dr. Walter Traub Gwenigale, Medical Director; and Bong County Medical Director

Dr. Alappat Francis David, Physician

Mr. Stewart, General Manager

O. Curran Lutheran Hospital, Zorzor (P.O. Box , Monrovia):

Dr. Erik Svenkerud, Medical Director

P. Lofa County Government, Boinjama:

Honorable Thomas N. Brima, Superintendent of Lofa County

Q. Voinjama Hospital:

Dr. ^{N.}Ramamoorthy, Medical Director; and Lofa County Medical Director

Dr. Ivan Camanor, Physician

Dr. George M. Berg, Chief of Party, USAID Lofa County Rural Health Project
(see #C; P.O. Box 1445, Monrovia)

R. Village of Barkaimai, Lofa County:

Lansana Kanneh, outgoing Chief

Mabulu Dulleh, incoming Chief

Mr. Dukuly, Principal, Barkaimai Elementary School

(APPENDIX II)

S. Barkaimai Health Post:

Mr. James Nah, Physician's Assistant

Mrs. Mary Yallah, Midwife

Mr. Mamadee Dolleh, Physician's Aide

T. Swedish Pentecostal Mission Clinic and Maternity Center, Foya Kamara:

Ms. Irene Ståhlberg, head nurse (P.O. Box 123, Monrovia)

U. Konia Health Center:

Mr. Daniel Dalton, Physician's Assistant

Ms. Ester Cole, Midwife

V. Health Center at President Tolbert's Farm, near Gblatuah:

CAPT. Joseph L. Johnson, Medical Officer, MSC--Physician's Assistant

MAJ. Kinney, Commandant at President's Farm

W. Village of Beyanstown, Lofa County:

Mr. Beyan, Chief

X. Ganta United Methodist Hospital:

Dr. Ring Decima, Physician

Y. LAMCO Guest House, LAMCO Iron Mine, Yekepa:

Mr. Schmidt, General Manager

Ms. "Jewell", Hostess at Mess Hall

Z. LAMCO Hospital, LAMCO Iron Mine, Yekepa (c/o LAMCO/Yekepa, Roberts International Airport):

Dr. Warsay Sirleaf, Chief Medical Officer and Nimba County Medical Director

Dr. Anders Björkman, Research Officer, LIBR-LAMCO Malaria Project
(from the Carolinska Institute, Stockholm, Sweden)

(APPENDIX II)

Z. LAMCO Hospital (continued):

Dr. Michael Wilcox, Research Officer, LIBR-LAMCO Malaria Project
(from Upsala, Sweden)

Mr. Peter Komak, X-Ray Assistant (translator for team at Lugbeyee)

AA. Regional YMCA, Yekepa (c/o LAMCO/Yekepa, Roberts International Airport):

Mr. Orwar Alnesið, Regional Director

BB. Village of Lugbeyee, Nimba County:

Mr. Quoi Duo, Chief

Mr. Stephen Belleh, Quarter-Chief

Mr. James Paye, Aide at YMCA Clinic (translator for team at Lugbeyee)

Mr. James Lakpor, Villager (translator for team at Lugbeyee)

Mr. Peter S. Dahn, Chairman, Lugbeyee Public School

Mr. Amos Nya Plu, Principal, Lugbeyee Public School

Mr. Sylvester Collins, Vice-Principal, Lugbeyee Public School

Mr. Edward Suah, Teacher, Lugbeyee Public School

Mr. John Fangah, Principal, DoKie Memorial Jr. High School, Sanniquellie

APPENDIX III. BIBLIOGRAPHY: ONCHOCERCIASIS IN LIBERIA AND NEARBY COUNTRIES; PARASITOLOGY AND HISTOPATHOLOGY OF ONCHOCERCIASIS; OCULAR ONCHOCERCIASIS; ENTOMOLOGY OF SIMULIUM SPECIES; AND THE LOFA COUNTY RURAL HEALTH PROJECT

(* = Publications or reports by the Oncho. Team members or their contacts)

- Anderson J & Fuqlsang H (1973a). Living microfilariae of Onchocerca volvulus in the cornea. Brit. J. Ophthal. 57, 712.
- Anderson J & Fuqlsang H (1973b). Variation in numbers of microfilariae of Onchocerca volvulus in the anterior chamber of the human eye. Trans. Roy. Soc. Trop. Med. Hyg. 67, 544-548.
- Anderson J, Fuqlsang H, Hamilton PJS & Marshall TFdeC (1974). Studies on onchocerciasis in the United Cameroon Republic. I. Comparison of populations with and without Onchocerca volvulus. Ibid. 68, 190-208.
- APHA (1975). Lofa County Rural Health Project--Liberia, West Africa. Report submitted by the American Public Health Association, Washington, D.C. to the U.S. Agency for International Development, Washington, D.C. (based on a study during Feb-Apr 75 by an APHA consultants team of Hood TH, Marnane PJH, Selwyn BJ & Brasfield A).
- APHA (1977). Environmental Health Assessment--Liberia. Report submitted by APHA to USAID, Washington, D.C. (based on a study during Feb-Mar 77 by an APHA consultants team of Gibson U, Grigsby M, Schalie HVD & Ruiz-Tiben E).
- Brinkmann US (1974). The assessment of microfilarial densities in skin snips from onchocerciasis patients under field conditions. (An LRU-TIH publication.) Tropenmed. Parasit. 25, 160-166.
- *Buck AA, Anderson RI, Conston JAC Jr, Wallace CK, Connor DH, Harman LE Jr, Donnor MV & Ganley JP (1971). Microfilaruria in onchocerciasis. A Clinical and epidemiologic follow-up study in the Republic of Chad. Bull. Wld. Hlth. Org. 45, 353-369.
- Burch TA, Qualls DM & Greenville HJ (1955). Onchocerciasis in Liberia. Amer. J. Trop. Med. Hyg. 4, 923-929.
- *Connor DH, Morrison NE, Kerdel-Vegas F, Berkoff HA, Johnson F, Tunnicliffe R, Failing FC, Hale LN & Lindquist K (1970). Onchocerciasis: Onchocercal dermatitis, lymphadenitis, and elephantiasis in the Ubangi Territory. Human Pathology 1, 553-579.
- Crosskey RW (1955). Observations on the bionomics of adult Simulium damnosum Theobald (Diptera, Simuliidae) in Northern Nigeria. Ann. Trop. Med. Parasit. 49, 142.
- Crosskey RW (1956). The distribution of Simulium damnosum Theobald in Northern Nigeria. Trans. Roy. Soc. Trop. Med. Hyg. 50, 379-392.
- Duke BOL (1962). A standard method of assessing microfilarial densities on onchocerciasis surveys. Bull. Wld. Hlth. Org. 27, 553-579.
- Duke BOL (1968a). The effects of drugs on Onchocerca volvulus. I. Methods of assessment, population dynamics of the parasite and the effects of diethylcarbamazine. Ibid. 39, 137-146.
- Duke BOL (1968b). Studies on factors influencing the transmission of onchocerciasis. VI. The infective biting potential of Simulium damnosum in different bioclimatic zones and its influence on the transmission potential. Ann. Trop. Med. Parasit. 62, 164-170.

(APPENDIX III)

- Frentzel-Beyme RR (1973). The prevalence of onchocerciasis and blindness in the population of the Bong Range, Liberia. (An LRU-TIH publication). Z. Trop. Parasit. 24, 339-357.
- Frentzel-Beyme R (1975a). The geographical distribution of Onchocerca volvulus in Liberia. (An LRU-TIH publication). Tropenmed. Parasit. 26, 70-87.
- Frentzel-Beyme RR (1975b). Visual impairment and incidence of blindness in Liberia and their relation to onchocerciasis. Ibid., 26, 469-488.
- Garms R & Post A (1967). Die Simulien des Republik Guinea, Westafrika. (An excellent literature review for West African black flies.) Int. Rev ges. Hydrobiol. 52, 1-36.
- Garms R (1972a). Vorkommen phoretischer Simulien in Liberia. (An LRU-TIH publication.) Z. Tropenmed. Parasit. 23, 302-307.
- Garms R (1972b). Epidemiologie der Onchocercose in Liberia. (An LRU-TIH publication.) Z. Parasitenk. 39, 70.
- Garms R (1973a). Zur Verbreitung von Simulium damnosum in Liberia. (An LRU-TIH publication.) Z. Tropenmed. Parasit. 24, 222-231
- Garms R (1973b). Quantitative studies on the transmission of Onchocerca volvulus by Simulium damnosum in the Bong Range, Liberia. (An LRU-TIH publication.) Ibid., 24, 358-372.
- Garms R (1973c). Eine neue Simulium-Art aus Liberia. (An LRU-TIH publication.) Rev. Zool. Bot. afr. 87, 758-763.
- Garms R (1974). Über die Verbreitung und Ökologie der Kriebelmücken (Simuliidae) in Liberia. (An LRU-TIH publication.) Z. angewandte Zool. 61, 63-90.
- Garms R & Vajime CG (1975). On the ecology and distribution of the species of the Simulium damnosum complex in different bioclimatic zones of Liberia and Guinea. (An LRU-TIH publication.) Tropenmed. Parasit. 26, 375-380.
- *Gibson DW, Connor DH, Brown HL, Fuglsang H, Anderson J, Duke BOL & Buck AA (1976). Onchocercal dermatitis: Ultrastructural studies of microfilariae and host tissues, before and after treatment with diethylcarbamazine (hetrazan). Amer. J. Trop. Med Hyg. 25, 74-87.
- *Gibson DW & Connor DH (1978). Onchocercal lymphadenitis: clinicopathologic study of 34 patients. Trans. Roy. Soc. Trop. Med. Hyg. 72, 137-153.
- Gratama S (1966). Onchocerciasis in the south-eastern territories of Liberia with studies on the role of Onchocerca volvulus and Wuchereria bancrofti in the pathogenesis of hydrocele and elephantiasis. Acta Leidensia 35, 1-135.
- Grunewald J (1976). The hydro-chemical and physical conditions of the environment of the immature stages of some species of the Simulium (Edwardsellum) damnosum complex (Diptera). Tropenmed. Parasit. 27, 438-454.
- Gunders AE & Neumann E (1963). A controlled study of the ocular findings in Liberian subjects with microfilariae of Onchocerca volvulus at the outer canthus of the eye. Am. J. Trop. Med. Hyg. 12, 761-766.

(APPENDIX III)

Hughes MH (1954). Some observations on the pathology of onchocerciasis. West African Med. J. 3, 157-161.

Kershaw WE, Duke BOL & Budden FH (1954). The distribution of microfilariae of O. volvulus in the human skin. Brit. Med. J. 2, 724-729.

*Knüttgen JH & Büttner DW (1968). Untersuchungen zur Epidemiologie und Bedeutung der Onchozerkose in Oberguinea. Z. Tropenmed. Parasit. 19, 1-42.

Kuhlow F & Zielke E (1976). Distribution and prevalence of Wuchereria bancrofti in various parts of Liberia. (An LRU-TIH publication.) Tropenmed. Parasit. 27, 93-100.

*Langham ME, Frentzel-Beyme RR, Traub Z-D (1975). Intraocular pressure and onchocerciasis in Liberia. (With LRU-TIH collaboration.) Ophthalmic. Res. 7, 368-380.

*Langham MF, Traub Z-D & Richardson R (1978). A transepidermal chemotherapy of onchocerciasis. (At Firestone Medical Center.) Tropenmed. Parasit. 29, 156-162.

*LRU-TIH (1976). Annual Report of the Liberia Research Unit of the Tropical Institute Hamburg for the year 1976. This includes several research reports on onchocerciasis in Liberia:

*Albiez E, Büttner DW & Schulz-Key H. Pilot project on the effects of nodulectomies in onchocerciasis patients. p. 15-19; (includes data on village of Mawua = Mauwa).

*Albiez E. Clinical investigations on onchocerca nodules. p. 20.

*Schulz-Key H, Albiez E & Büttner DW. Isolation of adult Onchocerca volvulus from nodules. p. 21.

*Schulz-Key H & Albiez E. Wormburden of Onchocerca volvulus in the hyperendemic village Wodee, Montserrado County. p. 21-25.

*Schulz-Key H & Albiez E. Comparative studies on the quantitative assessment of microfilarial concentrations in skin snips. p. 26-28.

Schulz-Key H. Quantitative studies on the transmission of Onchocerca volvulus by Simulium damnosum in three villages in Montserrado and Bong Counties. p. 28-31. (Includes data on Mawua = Mauwa.)

*Zielke E, Schulz-Key H & Albiez E. Studies on the development of Onchocerca volvulus in mosquitoes. p. 31-32.

The Annual Report also includes combined W. bancrofti and O. volvulus in several Kissi Chiefdom villages near Foya Kamara, upper-Lofa Co.:

Chlebowsky HO & Zielke E. Filariasis and onchocerciasis infections in the project villages in upper-Lofa County. p. 7-9.

Chlebowsky HO. DEC-treatment in four villages in upper-Lofa County. p. 10-13.

(APPENDIX III)

*LRU-TIH (1977). Annual Report of the Liberia Research Unit of the Tropical Institute Hamburg for the year 1977. This includes several research reports on onchocerciasis in Liberia--some follow-ups of those for 1976:

*Albiez EJ, Büttner DW & Schulz-Key H. Pilot project on the effects of nodulectomies in onchocerciasis patients. p. 14-15. (Includes Mawua.)

*Schulz-Key H, Albiez EJ & Büttner DW. Worm burden of Onchocerca volvulus in one meso- and in two hyperendemic villages in the Liberian rain-forest. p. 16-18. (Includes Mawua.)

*Weiss U & Büttner DW. Worm burden of children with onchocerciasis. p. 19-20.

Wolf H. Treatment of onchocerciasis patients with metrifonate, p. 21-22. (Includes Mawua.)

*Schulz-Key H, Albiez EJ & Büttner DW. Worm burden of Onchocerca volvulus in a hyperendemic village in Upper Volta. p. 22-24.

*Schulz-Key H, Albiez EJ, Büttner DW & Brinkmann UK. Comparative studies on the quantitative assessment of microfilarial densities in onchocerciasis. p. 25-26.

Schulz-Key H. A simple technique to assess the total number of microfilariae in skin snips in onchocerciasis. p. 26-28.

Schulz-Key H & Omar MS. Acid phosphatase activity in the larval stages of Onchocerca volvulus. p. 28-30.

Schulz-Key H. Quantitative studies on the transmission of Onchocerca volvulus by Simulium damnosum in Mauwa, Bong County. p. 31.

Zielke E. Attempts to infect mosquitoes with Onchocerca volvulus, Loa loa and Dipetalonema perstans. p. 32-33.

This Annual Report also includes combined W. bancrofti and O. volvulus in Kissi villages near Foya Kamara, upper-Lofa Co. (follow-ups to 1976):

Chlebowsky HO & Zielke E. Filariasis and onchocerciasis infections in the project villages in upper Lofa County. p. 7-10.

Chlebowsky HO. DEC-Treatment in four villages in upper Lofa County. p. 11-12.

Lewis DJ (1959). Observations on Simulium damnosum in the Southern Cameroons and Liberia. Ann. Trop. Med. Parasit. 54, 208-223.

Mazzotti L (1958). Posibilidad de utilizar como medio diagnostico en la onchocercosis, las reacciones alergicas consecutivas a la administracion de "Hetrazan". Rev. Inst. Salubr. Enferm trop. (Mex.) 9, 235-237.

----- insert Miller MF & Franz KN (1958).-----> (p. 89)

Neumann E & Zauberman H (1965). Glaucoma survey in Liberia. Am. J. Ophthal. 59, 8-12.

Neumann E & Gunders AE (1963). Ocular lesions of onchocerciasis in Liberia. Ibid., 56, 573-588.

(APPENDIX III)

- Nelson GS (1970). Onchocerciasis. (A comprehensive review.) Advances in Parasitology 8, 173-224.
- Neppert J (1974). Cross-reacting antigens among some filariae and other nematodes. (An LRU-TIH publication.) Tropenmed. Parasit. 25, 454-463.
- Neppert J & Warns C-M (1974). Mit Ascaris-, Hakenwurm- und Onchocerca-Antigenen kreuzreagierende Seren aus Liberia, Westafrika. (An LRU-TIH publication.) Ibid., 25, 492-497.
- Neppert J (1975). Die Closed Hexagon Immunodiffusion (CHI-Test) in der Serodiagnostik der Onchocercose. (An LRU-TIH publication.) Zbl. Bakt. Hyg., I. Abt. Orig. A 231, 297-300.
- Nnochiri E (1964). Observations on onchocercal lesions seen in autopsy specimens in Western Nigeria. Ann. trop. Med. Parasit. 58, 89-93.
- Paul EV & Zimmerman LE (1970). Some observations on the ocular pathology of onchocerciasis. Human Pathology 1, 581-594.
- Quillevere D, Razet P & LePiver MM (1976^a). Etude du complexe Simulium damnosum en Afrique de l'Ouest. III. Etude de la morphologie larvaire des cytotypes presents en Cote d'Ivoire. Cah. O.R.S.T.O.M., ser. Ent. Med. et Parasitol. 14, 245-258.
- Quillevere D, Gouzy M, Sechan Y & Pendriez B (1976^b). Etude du complexe Simulium damnosum en Afrique de l'Ouest. IV. Analyse de l'eau des gites larvaires en saison seche. Ibid. 14, 315-330.
- Quillevere D, Sechan Y & Pendriez B (1977^a). Etude du complexe Simulium damnosum en Afrique de l'Ouest. V. Identification morphologique des femelles en Cote d'Ivoire. Tropenmed. Parasit. 28, 244-253.
- Quillevere D, Gouzy M, Sechan Y & Pendriez B (1977^b). Etude du complexe Simulium damnosum en Afrique de l'Ouest. VI. Analyse de l'eau des gites larvaires en saison des pluies; comparaison avec la saison seche. Cah. O.R.S.T.O.M., ser. Ent. med. et Parasitol. 15, 195-207.
- insert Reber & Hoeppli (1964); Rodger (1958a,b; 1959); Rodger & Brown (1957) -->(p.89
- Rodger FC (1960). The pathogenesis and pathology of ocular onchocerciasis. IV. The pathology. Amer. J. Ophthal. 49, 560-594.
- Russell HK (1972). A modification of Movat's pentachrome stain. Arch. Pathol. 94, 187-191.

- in a hyperendemic
- *Schulz-Key H & Albiez EJ (1977). Worm burden of Onchocerca volvulus/village of the rain-forest in West Africa. (An LRU-TIH publication.) Tropenmed. Parasit. 28, 431-438.
- *Schulz-Key H, Albiez EJ & Büttner DW (1977). Isolation of living adult Onchocerca volvulus from nodules. (An LRU-TIH publication.) Ibid., 28, 428-430.
- *USAID (1974). Proposal: Lofa County Rural Health Project--Liberia. (USAID Proposal drafted by Friedline RL & Hagel FC; Siegel SJ, clearance officer.) U.S. Agency for International Development Mission, Monrovia, Liberia; dated 23 Oct 74; approx. 70 pages, including Exhibits A-O. (Copy of proposal supplied to team by Dr. Paul Mertens, USAID & TNIMA.)
- *USAID (1976). Health Facilities & Population Served for Lofa County - Liberia. (USAID consultants' report by Fuchs M & Salifu H.) USAID Mission, Monrovia, Liberia; dated Feb 76; 3 pages. (Received as an attachment to USAID (1978), from Dr. Mertens, USAID & TNIMA.)
- *USAID (1978a). Status Summary of the Lofa County Rural Health Project, May, 1978. (USAID status report; authors not stated.) USAID Mission, Monrovia; and USAID Lofa County Rural Health Project, Voinjama, Liberia (Dr. G. Berg, Chief of Party). (Copy, with USAID (1976) attached, received from Dr. Mertens, USAID & TNIMA.) 9 pages, excluding 3-page attachment.
- *USAID (1978b). Programmatic and Research Strategy for the Control of Major Endemic Diseases in Africa. (USAID Report; authors not stated.) Health and Nutrition Division, Office of Development Resources, Bureau for Africa, U.S. Agency for International Development, Washington, D.C.; dated July 78; 43 pages. (Copy of report supplied to team by Dr. E. Cross, Bureau for Africa, USAID/Washington.)
- Voelker J (1972). Über unbekannte Filarienlarven aus dem Onchocercose-Überträger Simulium damnosum in Liberia. Z. Parasitenk. 39, 70-71. (An LRU-TIH publication.)
- Voelker J & Garms R (1972). Zur Morphologie unbekannter Filarienlarven aus dem Onchocercose-Überträger Simulium damnosum und aus S. kenyae in Liberia und zur Frage der möglichen Endwirte. (An LRU-TIH publication.) Z. Tropenmed. Parasit. 23, 285-301.
- Vajime CG & Dunbar RW (1975). Chromosomal identification of eight species of the subgenus Edwardsellum near and including Simulium (Edwardsellum) damnosum complex (Diptera). (An LRU-TIH publication.) Tropenmed. Parasit. 26, 111-138.
- Von Noorden GK & Buck AA (1968). Ocular onchocerciasis. An ophthalmological and epidemiological study in an African village. Arch. Ophthalm. 80, 26-34.
- WHO (1966). WHO Expert Committee on Onchocerciasis--Technical Report (1966). Wld. Hlth. Org. techn. Rep. Ser., No. 335. World Health Organization, Geneva; 92 pages.

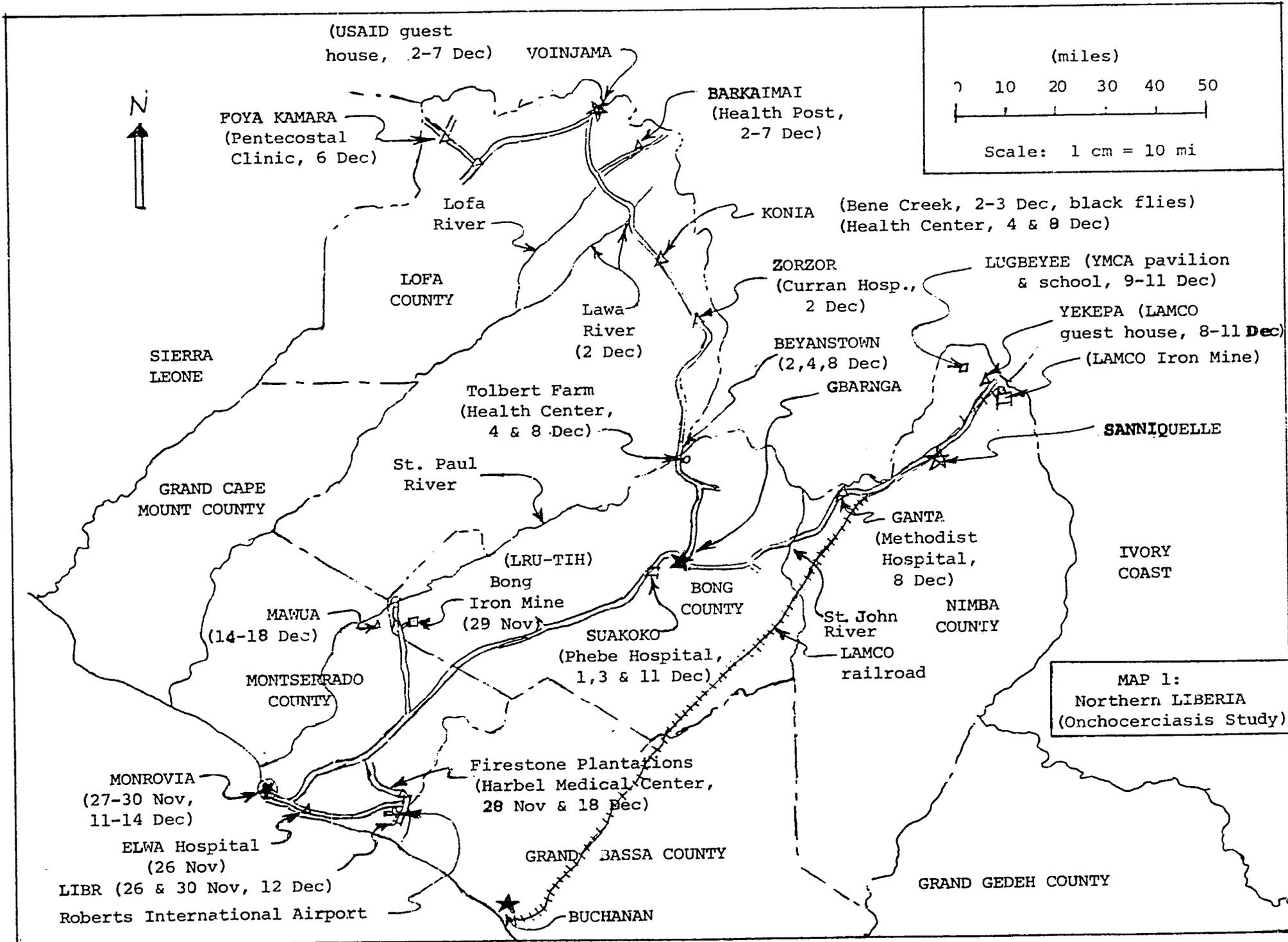
(APPENDIX III)

-----insert WHO (1973) ----->(below)

- *WHO (1974). Onchocerciasis: Symptomatology, pathology, diagnosis.
(A WHO monograph; Buck AA, Ed.; Contributors: Anderson J, Buck AA, Budden FH, Connor DH, Fuglsang H, Picq JJ, Rolland A & Waddy BB.)
World Health Organization, Geneva; 80 pages.
- Zielke E (1977a). Further studies on the development of Onchocerca volvulus in mosquitoes. (An LRU-TIH publication.) Trans. Roy. Soc. Trop. Med. Hyg. 71, 546-547.
- Zielke E (1977b). On the escape of infective filarial larvae from the mosquitoes. (An LRU-TIH publication.) Tropenmed. Parasit. 28, 461-466.
- *Zielke E, Schulz-Key H & Albiez EJ (1977). On the development of Onchocerca volvulus in mosquitoes. (An LRU-TIH publication.) Ibid., 28, 254-257.

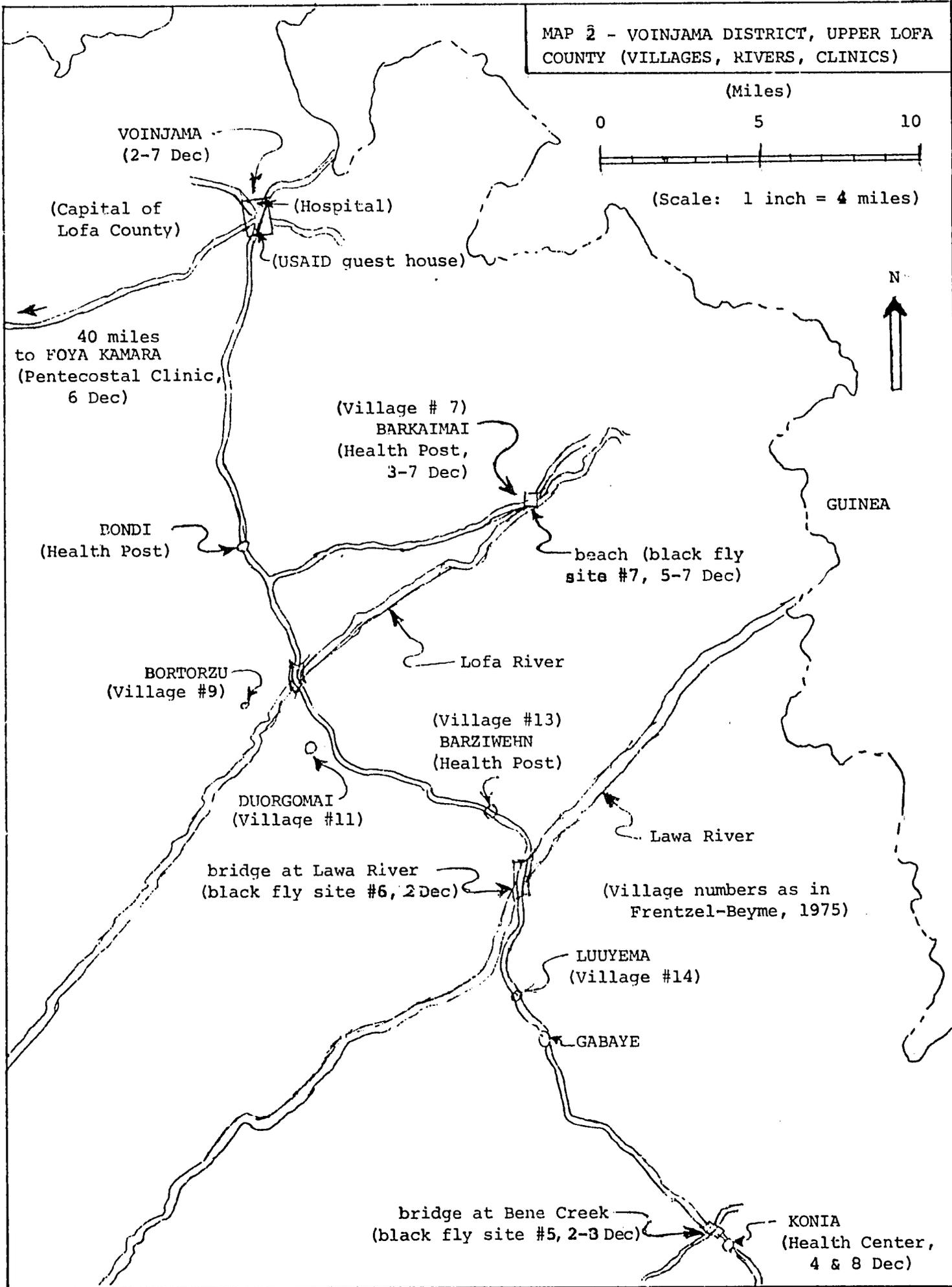
Inserts for APPENDIX III (alphabetic order):

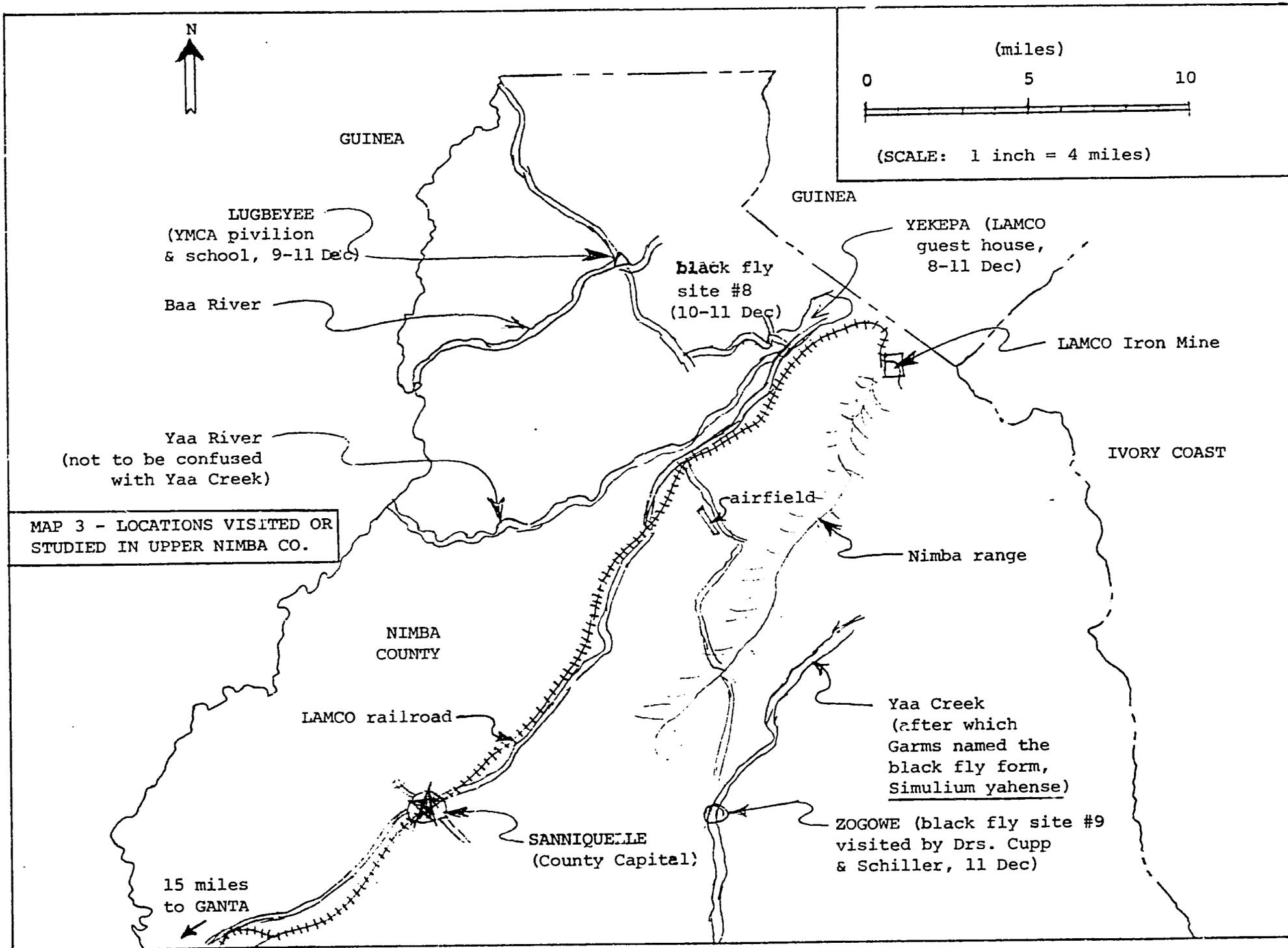
- Miller MJ & Franz KN (1958). Some clinical aspects of onchocerciasis in Liberia. Am. J. Trop. Med. Hyg. 7, 558-560.
- Reber EW & Hoeppli R (1964). The relationship between macroscopic skin alterations, histological changes and microfilariae in one hundred Liberians with onchocercal dermatitis. Z. Tropenmed. Parasit. 15, 153-163.
- Rodger FC (1959). Blindness in West Africa. H.K. Lewis & Co., Ltd., London; 262 pages.
- Rodger FC (1958a). Posterior degenerative lesion of onchocerciasis. Brit. J. Ophthalmol. 42, 21-37.
- Rodger FC (1958b). Eye disease in the African continent. Am. J. Ophthalmol. 45, 343-358.
- Rodger F & Brown JAC (1957). Assessment of the density of infection with onchocerciasis and the probable level of safety from its ocular complication. Trans. Roy. Soc. Trop. Med. Hyg. 51, 271.
- WHO (1973). World Health Organization Chronicle: Prevention of blindness. Wld. Hlth. Org. Chron. 27, 21-27. Also: WHO Study Group on the Prevention of Blindness. Wld. Hlth. Org. techn. Rep. Ser., No. 518 (1973).



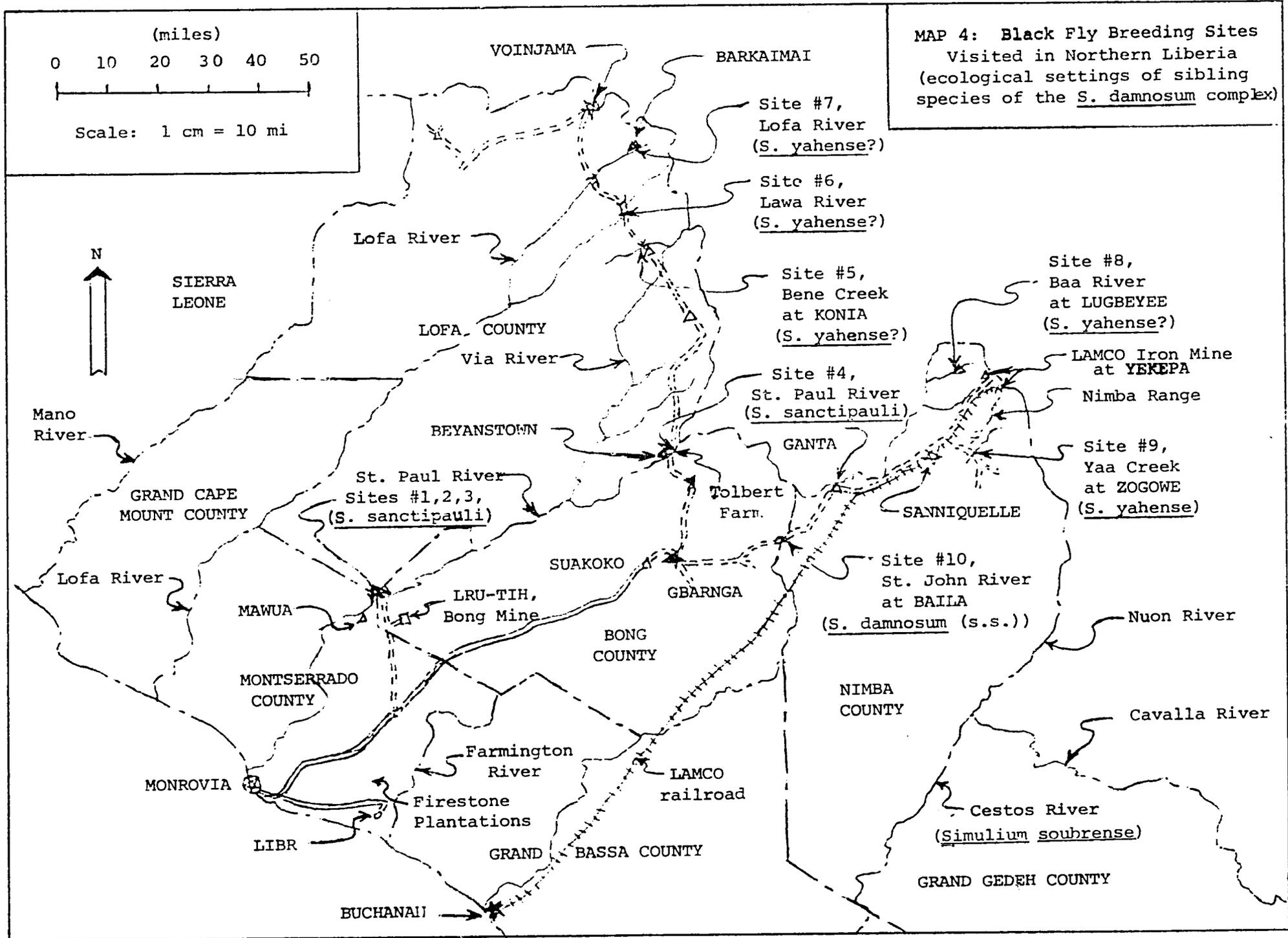
MAP 1:
Northern LIBERIA
(Onchocerciasis Study)

MAP 2 - VOINJAMA DISTRICT, UPPER LOFA COUNTY (VILLAGES, RIVERS, CLINICS)





MAP 3 - LOCATIONS VISITED OR STUDIED IN UPPER NIMBA CO.



MAP 4: Black Fly Breeding Sites
 Visited in Northern Liberia
 (ecological settings of sibling
 species of the S. damnosum complex)

(miles)
 0 10 20 30 40 50
 Scale: 1 cm = 10 mi



SIERRA
 LEONE

Mano
 River

GRAND CAPE
 MOUNT COUNTY

Lofa River

MAWUA

MONTERRADO
 COUNTY

MONROVIA

LIBR

BUCHANAN

LOFA COUNTY

Via River

BEYANSTOWN

St. Paul River
 Sites #1,2,3,
 (S. sanctipauli)

LRU-TIH,
 Bong Mine

SUAKOKO

BONG
 COUNTY

Farmington
 River

Firestone
 Plantations

GRAND

BASSA COUNTY

BARKAIMAI

Site #7,
 Lofa River
 (S. yahense?)

Site #6,
 Lawa River
 (S. yahense?)

Site #5,
 Bene Creek
 at KONIA
 (S. yahense?)

Site #4,
 St. Paul River
 (S. sanctipauli)

GANTA

Tolbert
 Farm.

GBARNGA

Site #10,
 St. John River
 at BAILA
 (S. damnosum (s.s.))

NIMBA
 COUNTY

LAMCO
 railroad

SANNIQUELLE

Site #8,
 Baa River
 at LUGBEYEE
 (S. yahense?)

LAMCO Iron Mine
 at YEKEPA

Nimba Range

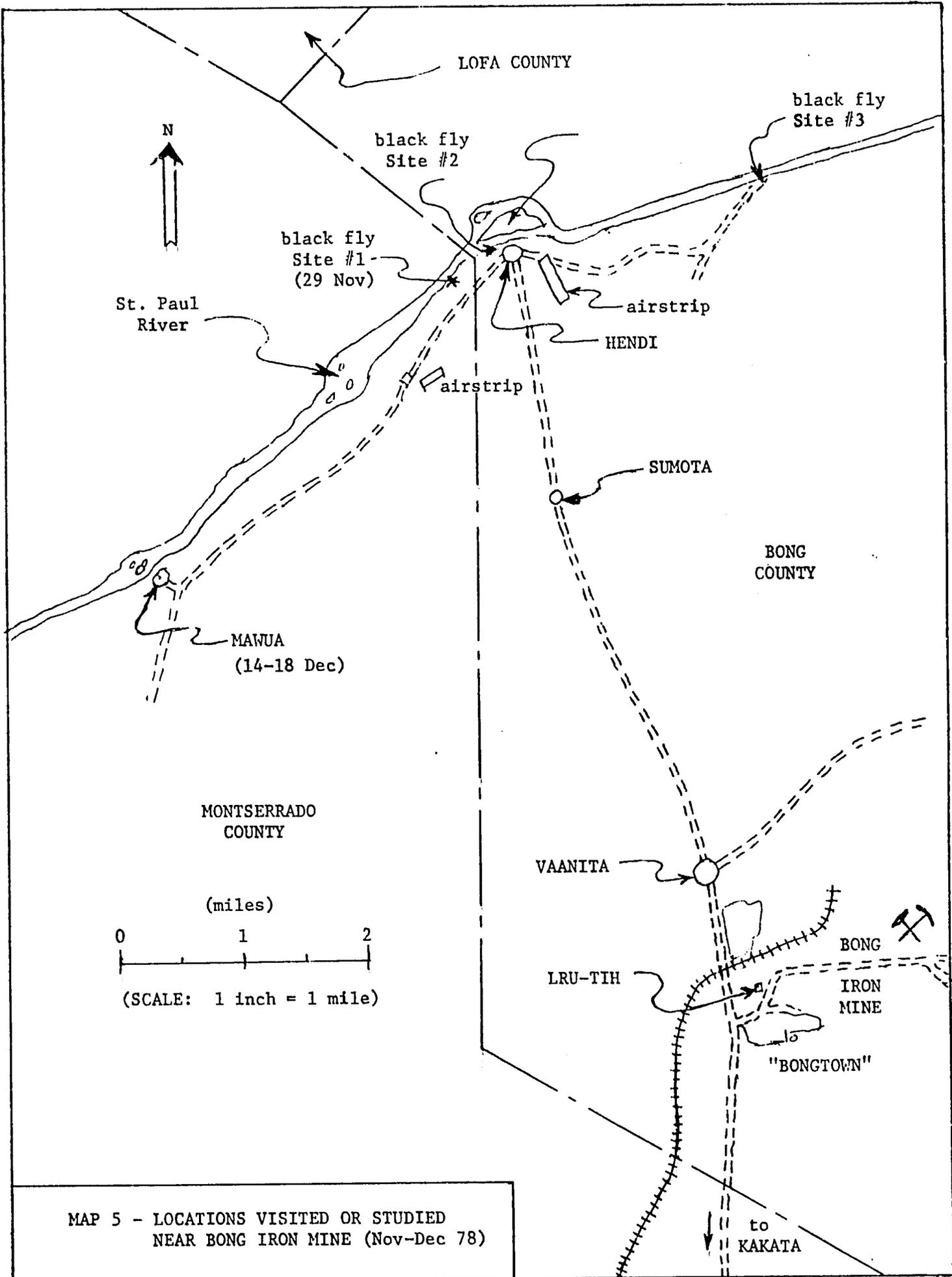
Site #9,
 Yaa Creek
 at ZOGOWE
 (S. yahense)

Nuon River

Cavalla River

Cestos River
 (Simulium soubrense)

GRAND GEDEH COUNTY



MAP 5 - LOCATIONS VISITED OR STUDIED
NEAR BONG IRON MINE (Nov-Dec 78)

TABLE 1. Signs, Symptoms and Parasitological Parameters on Onchocerciasis Patients at Barkaimai Clinic, Lofa Co.

Patient No.	AFIP Accession No.	Age Sex	Skin Snips: mf in thighs		Skin Test with mf exoantigen*: wheal (mm x mm)	Blood Specimen Taken**	Oncho. nodules	Clinical Signs of onchocercal dermatitis	Fullness of Lymph Nodes***
			L	R					
1	1679374	27/F	0	0	Pos. (15 x 17)	Yes	--	papules, arms & legs	--
2	1679375	46/M	0	0	Pos. (11 x 14)	Yes	--	pruritus & atrophy, shins	L,R ingu
3	1679376	60/M	0	0	Pos. (18 x 15)	Yes	--	pruritus, back & arms; depigment'n, L,R shins	L,R ingu
4	1679377	20/M	0	0	Pos. (15 x 16)	Yes	R iliac	changes, L,R shins	--
5	1679378	90/M	0	0	Neg.	Yes	L iliac (calcified)	---	--
6	1679379	35/M	8	2	Pos. (11 x 14)	Yes	L troch.; L,R iliac	generalized pruritus, depigment'n, L,R shins	L ingu
7	1679380	45/F	0	0	Neg.	No	R iliac	--	--
8	1679381	70/F	5	0	Neg.	Yes	L troch.	hypopigment'n, L,R shins	L,R ingu
9	1679382	27/F	0	0	Pos. (11 x 15)	Yes	R iliac	--	L,R fem
10	1679383	75/F	4	0	Pos. (14 x 22)	Yes	sacral	atrophy, L,R thighs & knees	--
11	1679384	75/M	0	0	Pos. (10 x 13)	Yes	cluster	atrophy, scaling, shins & knees	L,R fem
12	1679385	32/M	10	3	Pos. (14 x 16)	Yes	L ribs	wrinkling, L,R thighs & legs	L,R fem
13	1679386	40/M	5	1	Pos. (11 x 13)	Yes	L iliac	severe generalized pruritus	L,R fem
14	1679387	52/M	0	0	Pos. (14 x 19)	Yes	R troch.	papules, trunk & abdomen	L,R fem
15	1679388	80/M	0	0	Pos. (16 x 17)	No	--	--	--
16	1679389	45/F	0	0	Pos. (11 x 15)	Yes	--	--	L,R fem & ingu
# 17	1679390	50/M	1	10	Pos. (15 x 15)	Yes	L,R iliac	depigment'n, L,R shins	--
19	1679391	65/M	0	0	Pos. (18 x 20)	Yes	R iliac, L,R troch.	depig., penis	(hernia)
20	1679392	76/M	0	0	Pos. (13 x 18)	Yes	L,R iliac, L,R troch.	wrinkling & atrophy--arms, legs, thighs, buttocks	L,R fem, L,R ingu
21	1679393	55/F	0	0	Pos. (14 x 15)	Yes	L,R iliac & troch.; sacral	wrinkling & atrophy-- L,R legs & thighs	L,R fem, L,R ingu
22	1679394	35/M	-	-	Not Done	No	R iliac, L troch.	hyperpig'd macules--thighs & buttock; sore on heel	L fem
23	1679395	45/M	-	-	" "	No	--	depigment'n, L,R shins	L,R fem & ingu
24	1679396	30/M	-	-	Pos. (15 x 15)	Yes	--	(Skin & blood tests only, on Liberian physician)	

* Exoantigen (0.5 ml @ 1.2 mg protein/ml) from microfilariae of *O. volvulus* cultured *in vitro* (Methods, Section II.J.2).

** Blood collected by venipuncture and serum separated for immunochemical studies at Johns Hopkins University (II.J.4).

*** abbreviations: fem = femoral node; ingu = inguinal node; troch. = trochanter; iliac = iliac spine.

#(Non-oncho. patient No. 18, AFIP #1679373y biopsied lesion on penis; diagnosed at AFIP as squamous cell carcinoma).

TABLE 1.2. Reactions to Treatment with Diethylcarbamazine or Mintezol for Onchocerciasis Patients at Barkaimai

Patient No.	Treatment*			Exam. for Reaction to Rx			Biopsy Specimen			
	Time	Type	Site	Time	Site of rxn.	Clinical Description	No.	Time after Treatment	Site of Bx	Comments
1	0 hr	Topical DEC	R leg	23 hr	(R leg	No Change)			None	
2	0 hr	Nivea control	R leg	19 hr	(R leg	No Change)			None	
	19 hr	Topical Mintezol	R leg	47 hr	(R leg	"heavy"; no itching)			None	
3	0 hr	Nivea control	R leg	51 hr	(R leg	No Change)			None	
4		None			None				None	
5	0 hr	Topical DEC	R leg	22 hr	(R leg	No Change)			None	
	22 hr	Topical DEC	R leg	48 hr	(R leg	No Change)			None	
6	0 hr	Topical DEC	R leg	19 hr	RU thigh	papular erupt'n			None	
	19 hr	Topical DEC	R leg	45 hr	" "	" " "	6A	45 hr	RU Thigh	(6-mm punch)
	45.3 hr	Topical DEC	R leg	70 hr	RU thigh	severe pap.erup.	6B	70 hr	RU Thigh	(" ")
							6C	pre-DEC	L Thigh	(fixed skin snip)
							6D	" "	R Thigh	(" " ")
7		None			None				None	
8	0 hr	Topical Mintezol	R leg	22 hr	(R leg	No Change)	8A	22 hr	RU Thigh	(6-mm punch)
							8B	pre-Mint.	L Thigh	(fixed skin snip)
							8C	pre-Mint.	R Thigh	(fixed skin snip)
9	0 hr	Topical DEC	R leg	20 hr	(R leg	No Change)			None	
10	0 hr	Topical DEC	R leg	20 hr	RU thigh	pruritis, (no papules)			None	
	20 hr	Topical DEC	R leg	45 hr	" "	" " "			None	
	45 hr	Topical DEC	R leg	67 hr	" "	" " "	10A	67 hr	RU Thigh	(6-mm punch)
							10B	pre-DEC	L Thigh	(fixed skin snip)
							10C	" "	R Thigh	(" " ")
11	0 hr	Topical Mintezol	R leg	29 hr	(R leg	No Change)			None	
12	0 hr	Topical DEC	R leg	(12 hr	RU thigh	patient started to itch)				
				22 hr	RU thigh	papular eruption	12A	22 hr	RU Thigh	(6-mm punch)
	22.1 hr	Topical DEC	R leg	45 hr	RU thigh	" " "			None	
	45 hr	Topical DEC	R leg	71 hr	RU thigh	severe pap.erup.	12B	71 hr	RU Thigh	(6-mm punch thru a 1.5 mm papule)
							12C	pre-DEC	L Thigh	(fixed skin snip)
							12D	pre-DEC	R Thigh	(" " ")
13	0 hr	Topical DEC	R leg	21 hr	RU thigh	crusted papules			None	
	23 hr	Topical DEC	R leg	49 hr	RU thigh	" " "	12A	49 hr	RU Thigh	(6-mm punch)
							12B	pre-DEC	L Thigh	(fixed skin snip)
							13B	pre-DEC	R Thigh	(" " ")

(continued on next page)

TABLE 2. (continued)

Patient No.	Treatment*			Exam. for Reaction to Rx			Biopsy Specimen			
	Time	Type	Site	Time	Site of rxn.	Clinical Description	No.	Time after Treatment	Site of Bx	Comments
14	0 hr	Topical DEC	R leg	19 hr	RU thigh	pruritis			None	
	19 hr	Topical DEC	R leg	48 hr	RU thigh	papular erupt'n	14A	48 hr	RU Thigh	(6-mm punch)
					(LU thigh--untreated)		14B	48 hr	LU Thigh	(6-mm punch)
							14C	pre-DEC	L Thigh	(fixed skin snip)
15	0 hr	skin test/exo-Ag	R arm	14 min	R arm--injxn.	site, wheal	15A	25 min	R arm,wheal	(6-mm punch)
							15B	pre-s.t.	L Thigh	(fixed skin snip)
							15C	" " "	R Thigh	(" " ")
16	0 hr	100 mg oral DEC	systemic	24 hr	L,R eyes	peri-orb. edema	16A	24 hr	L o.canthus	(4-mm punch)
				24 hr	L,R legs	severe pruritis	16B	pre-DEC	L Thigh	(fixed skin snip)
				24 hr	fem nodes	tender	16C	pre-DEC	R Thigh	(" " ")
17	0 hr	Topical LEC	R leg	22 hr	RU thigh	papular erup.	17A	23 hr	RU Thigh	(6-mm punch)
	23 hr	Topical DEC	R leg	45 hr	RU thigh	" "	17B	pre-DEC	L Thigh	(fixed skin snip)
	45 hr	Topical DEC	R leg	70 hr	RU thigh	" "	17C	pre-DEC	R Thigh	(" " ")
(18)	0 hr	None		0 hr	penis	sq. carcinoma	18A	0 hr	Foreskin	(excision)
19	0 hr	skin test/exo-Ag	R arm	30 min	R arm--injxn.	site, wheal	19A	50 min	R arm,wheal	(6-mm punch)
	40 min	Topical DEC	R leg	48 hr	(R leg--little or no rxn.)		19B	pre-DEC	L Thigh	(fixed skin snip)
							19C	pre-DEC	R Thigh	(" " ")
20	0 hr	Nivea control	R leg	19 hr	(R leg	no change)			None	
	19 hr	Topical Mintezol	R leg	47 hr	(R leg	no change)			None	
21	0 hr	Nivea control	R leg	19 hr	(R leg	no change)			None	
	19 hr	100 mg oral DEC	systemic	46 hr	general	severe pruritis			None	
(22)		--		--	heel	sore--not oncho.	22A	no Rx	lesion, heel	(6-mm punch)
23	0 hr	100 mg oral DEC	systemic	(3 hr	general	began itching; Mazzotti reaction)				
				19 hr	general	severe pruritis			None	
24	19 hr	100 mg oral DEC	systemic	48 hr	general	severe pruritis			None	
		None			None				None	

* Topical DEC: 2% DEC in Nivea milk base, rubbed over entire R leg--Methods, Section II.G.1.

Nivea control: Nivea milk, rubbed over entire R leg--II.G.1.

Topical Mintezol: Thiobendazol liquid ("Mintezol"), rubbed over entire R leg--Methods, Section II.G.4.

Oral DEC: a single oral dose of 100 mg DEC ("Banocide")--Methods, Section II.G.2.

TABLE 3. Signs, Symptoms and Parasitological Parameters on Onchocerciasis Patients at Lugbeyee, Nimba Co.

Patient No.	AFIP Accession No.	Age Sex	Skin Snips: mf in thighs		Skin Test with mf exoantigen*: wheal (mm x mm)	Blood Specimen Taken**	Oncho. nodules	Clinical Signs of onchocercal dermatitis	Fullness of Lymph Nodes
			L	R					
31	1679397	40/M	0	3	Pos. (15 x 12)	Yes	L,R troch.	--	L,R fem & ingu
32	1679398	55/M	0	2	Pos. (10 x 15)	Yes	sacral, R iliac	--	--
33	1679399	50/M	15	4	Pos. (15 x 14)	Yes	sacral, L iliac	--	--
34	1679400	26/F	3	6	Pos. (14 x 11)	Yes	sacral	--	--
35	1679401	65/F	34	21	Pos. (15 x 25)	Yes	R iliac, L troch.	--	--
36	1679402	30/M	3	0	Pos. (12 x 14)	Yes	sacral	--	L,R fem & ingu
37	1679403	55/F	2	5	Pos.	Yes	L iliac atrophy, buttock & thigh	--	--
38	1679404	35/M	5	0	Doubtful Pos.	Yes	R iliac & troch.	--	--
39	1679405	56/M	0	1	Neq.	Yes	--	gale filarienne	--
40	1679406	50/F	20	43	Pos. (10 x 11)	Yes	L iliac	--	--
41	1679407	55/M	0	8	Doubtful Pos.	Yes	sacral, R iliac	--	--
42	1679408	32/M	0	9	Pos. (10 x 10)	Yes	L troch.	--	--
43	1679409	52/M	0	0	Pos. (26 x 15)	Yes	sacral, R iliac	gale filarienne	L,R fem
49 = 44	1679410	50/F	1	3	Pos. (10 x 10)	Yes	L,R troch.	--	--
45	1679411	38/M	1	1	Pos. (13 x 13)	Yes	R iliac	--	--
46	1679412	28/M	--	--	--	--	--	--	--
47	1679413	65/M	(no skin snips, skin tests or blood specimens taken for patients 46-65)			--	sacral, R thoch.	depigment'n, L thigh	--
48	1679414	62/M				--	--(eye test only)	--	--
50	1679416	50/M				--	sacral, R troch., L,R iliac, L rib	--	L,R fem
51	1679417	35/M				--	--	--	--
52	1679418	60/M				--	--	papules, R thigh, gale filarienne, buttock	--
53	1679419	60/M				--	-- (eye test only)	--	--
54	1679420	40/M				--	L iliac	papules, buttock	L,R fem & ingu
55	1679421	45/M				--	R iliac	papules, R thigh	L,R fem & ingu
56	1679422	40/M				--	sacral	--	L,R fem & ingu
57	1679423	28/M				--	-- (scars on face)--	--	L,R fem & ingu
58	1679424	50/M				--	sacral, R iliac	depigment'n, L,R shins	R fem
59	1679425	65/M				--	R iliac, L troch.	--	--
60	1679426	60/M				--	L buttock	depig., penis & scrotum	L,R fem
61	1679427	30/F				--	L iliac	gale filar., trunk & buttock	--
62	1679428	40/F				--	--	pruritus, trunk & chest	--
63	1679429	65/M				--	L troch.	lizard skin, thighs, buttocks	--
64	1679430	70/M				--	L ribs	papules, arms, legs & trunk	--
65	1679431	38/F				--	sacral	--	--

*, ** same as footnotes to Table I.

TABLE 4. Reactions to Treatment with Diethylcarbamazine for Onchocerciasis Patients at Lugbeeye

Patient No.	Treatment*			Exam. for Reaction to Rx			Biopsy Specimen			
	Time	Type	Site	Time	Site of rxn.	Clinical Description	No.	Time after Treatment	Site of Bx	Comments
31	0 hr	Topical DEC	R leg	24 hr	RU thigh	papular eruption			None	
				48 hr	RU thigh	less " "	31A	48 hr	RU thigh	(6-mm punch)
							31B	pre-DEC	L thigh	(fixed skin snip)
							31C	" "	R thigh	(" " ")
32	0 hr	Topical DEC	R leg	24 hr	RU thigh	slight pruritus		None		
33	0 hr	Topical DEC	R leg	(didn't return for followup)				None		
34	0 hr	Topical DEC	R leg	24 hr	RU thigh	sl. papular erupt'n		None	(itching began 8 hr post-Rx)	
35	0 hr	Topical DEC	R leg	23 hr	RU thigh	pruritus; no papules		None	(28 hr, used to catch flies;	
				47 hr	buttock	scratch marks			incr. itching of buttocks then)	
36	0 hr	Topical DEC	R leg	23 hr	RU thigh	papular eruption	36A	23 hr	RU thigh	(6-mm punch)
				47 hr	RU thigh	" "	36B	23 hr	LU thigh	(no Rx; 6-mm punch)
				47 hr		(& pruritus--	36C	pre-DEC	L thigh	(fixed skin snip)
				47 hr		face, L,R thighs)	36D	pre-DEC	R thigh	(" " ")
37	0 hr	Topical DEC	R leg	24 hr	(R leg	no change)		None		
	24 hr	Topical DEC	R leg	46 hr	R calf	slight itching		None		
38	0 hr	Topical DEC	R leg	23 hr	RU thigh	pruritus; no papules		None		
	23 hr	Topical DEC	R leg	(48 hr--didn't return for followup)				None		
39	0 hr	Topical DEC	R leg	23 hr	generalized pruritus			None	(itching began 6 hr post-Rx)	
	23 hr	Topical DEC	R leg	(48 hr--didn't return for followup)				None		
40	0 hr	Topical DEC	L,R legs	22 hr	L,R thighs	pruritus		None	(both legs treated by mistake)	
	22 hr	Topical DEC	R leg	(48 hr--didn't return for followup)				None		
41	0 hr	Topical DEC	R leg	22 hr	R leg	pruritus; no papules		None		
	22 hr	Topical DEC	R leg	45 hr	L,R thighs	pruritus; no papules		None		
42	0 hr	Topical DEC	R leg	22 hr	(R leg	no change)		None		
	22 hr	Topical DEC	R leg	(48 hr--didn't return for followup)				None		
43	0 hr	Topical DEC	R leg	22 hr	(R leg	no change)		None		
	22 hr	Topical DEC	R leg	(48 hr--didn't return for followup)				None		
44	0 hr	Topical DEC	R leg	(24 hr--didn't return for followup)				None		
45	0 hr	Topical DEC	R leg	20 hr	(R leg	no change)		None		
				45 hr	(R leg	no change)		None		
65	0 hr	Topical DEC	R leg	(24 hr--didn't return for followup)				None		
46		No Treatment				None		None		
48		No Treatment				None		None		

TABLE 4. (continued)

Patient No.	Treatment*			Exam. for Reaction to Rx			Biopsy Specimen			
	Time	Type	Site	Time	Site of rxn.	Clinical Description	No.	Time after Treatment	Site of Bx	Comments
47	0 hr	Intradermal DEC	L thigh	22 hr		generalized pruritus		None (no local reaction)		
50	0 hr	Intradermal DEC	L thigh	1 hr		generalized pruritus began		None		
				18 hr		generalized pruritus (injxn. site--swollen, warm, and indurated)	18A 18B	18 hr 18 hr	R thigh (opp. injxn.; 6-mm) L thigh (injxn. site; 6-mm)	
51	0 hr	Intradermal DEC	L thigh	2 hr		generalized pruritus			None	
				23 hr		generalized pruritus			None	
52	0 hr	Intradermal DEC	L thigh	22 hr		generalized pruritus			None	
53	0 hr	Intradermal DEC	L thigh	(24 hr--didn't return for followup)					None	
54	0 hr	Intradermal DEC	L thigh	15 min		pruritus began			None	
				90 min.		pruritus most intense at papules on buttock & L iliac			none	
				22 hr		no pruritus remains, but swelling & induration at injxn. site			None	
55	0 hr	Intradermal DEC	L thigh	2 hr		no pruritus			None	
56	0 hr	Intradermal DEC	L thigh	22 hr		no pruritus anywhere			None	
57	0 hr	Intradermal DEC	L thigh	20 min		face & chest--pruritus began			None	
				90 min		systemic pruritus;	57A	90 min	papule on buttock (6-mm punch)	
				8-22 hr		pruritus greatly reduced			None	
58	0 hr	Intradermal DEC	L thigh	5 hr		generalized pruritus began			None	
				22 hr		max. itching over nodules on L hip & L iliac spine			None	
59	0 hr	Intradermal DEC	R thigh	8 hr		L,R thighs, trunk--pruritus began			None	
			(had mud on L thigh)	20 hr		R thigh--blister @ injxn.	59A	20 hr	blister @ injxn. site (6-mm)	
60	0 hr	Intradermal DEC	L thigh	20 hr		L,R thighs--slight focal itching			None	
61	0 hr	Intradermal DEC	L thigh	20 hr		L,R thighs--slight itching			None	
62	0 hr	Intradermal DEC	L thigh	20 hr		no pruritus			None	
63	0 hr	Intradermal DEC	L thigh	20 hr		L thigh--itching most @ injxn.	63A	20 hr	blister @ injxn. site (6-mm)	
						slight itching, rest of body				
64	0 hr	Intradermal DEC	L thigh	(20 hr--didn't return for followup)					None	

* Topical DEC: 2% DEC in Nivea milk base, rubbed over entire R leg (L & R legs, patient 40)--Methods, Section II.G.1.

** Intradermal DEC: 25 mg DEC in 0.25 ml saline, injected intradermally into L Thigh (R thigh, patient 59)--II.G.3.

TABLE 5. Ophthalmologic Findings for Onchocerciasis Patients at Barkaimai

Patient No.*	Time After Treatment	Eye	Visual Acuity	Cornea**	Anterior Chamber	Iris	Lens	Fundus	Vision Loss	Ocular Oncho.	
2	24 hr after top. Mintezol	R	6/6	small punctate, centrally (FB?)	n	n	n	n	No	No	
		L	6/6	" " "	n	n	n	n	No	No	
3	48 hr after Nivea control	R	6/9	occasional mf & punctate keratitis	n	n	n	n	No	Yes	
		L	6/9	n	n	n	n	n	No	No	
6	72 h: after topica. DEC	R	6/6	occasional mf & punctate keratitis	n	n	n	drusen	No	Yes	
		L	6/6	occasional mf	n	n	n	drusen	No	Yes	
10	72 hr after topical DEC	R	6/9	n	n	n	uniform cataracts	n	No	No	
		L	6/9	pterygium	n	n		n	n	No	No
11	24 hr after top. Mintezol	R	6/9	n	n	n	n	n	No	No	
		L	6/6	small central superficial scar, (etiology?--possibly oncho.?)	n	n	n	chorio-retinitis (oncho.?)	No	Possibly	
12	72 hr after topical DEC	R	6/6	moderate mf & punctate keratitis	1 mf	n	n	n	No	Yes	
		L	6/6	" " " "	1 mf	n	n	n	No	Yes	
13	48 hr after topical DEC	R	6/6	occasional mf & mod. punctate keratitis	1 mf	n	n	n	No	Yes	
		L	6/6	" " " " " "	2 mf	n	n	n	No	Yes	
14	48 hr after topical DEC	R	6/9	punctate centrally (foreign body?)	n	n	n	n	No	No	
		L	6/9	n	n	n	n	n	No	No	
15	patient not treated	R	no light perception	dense total scar with superficial vascularization; central stromal defect plugged with iris	(right eye blind for 55 years; probably from measles that he had as small boy; blind about age 25; present age 80)					No	No
		L	6/6	superficial slight stromal haze with slight loss of tissue centrally	n	n	n	n	No	No	

*1,4,5, (No ophthalmologic examinations)
 7,8,9, " " "
 18,24 " " "

TABLE 5. (continued)

Patient No.*	Time After Treatment	Eye	Visual Acuity	Cornea**	Anterior Chamber	Iris	Lens	Fundus	Vision Loss	Ocular Oncho.		
16	24 hr after oral DEC	R, L	- (severe periorbital edema, both eyes, several hr after 100 mg oral DEC; edema of face, upper & lower lids; bilateral corneal edema; suspect iritis, but too much ambient light to determine flare)									
		R	6/24	numerous mf; few punctate keratitis sl. temporal & total infiltrates	n	min. stroma-- loss of frill	n	n	oncho. cornea, A.C.	Yes		
		L	6/18	numerous mf; occasional punctate ker.; nasal & temporal infiltrates	***	" "	n	****	" "	Yes		
				(L posterior pale--compatible with early form of proliferative oncho. chorioretinitis)								
17	72 hr after topical DEC	R	6/9	numerous mf nasally	n	n	n	n	No	Yes		
		L	6/9	n	n	n	n	n	No	No		
19	48 hr after topical DEC	R	6/9	n	n	n	n	#	No	No		
		L	6/9	n	n	n	n	#	No	No		
20	24 hr after top. Mintezol	R	6/9	occasional mf & punctate keratitis	1 mf	n	n	n	No	Yes		
		L	6/9	" " " " and slight temporal infiltrates	n	n	n	n	No	Yes		
21	24 hr after oral DEC	R	6/24	occasional mf; 1 punctate keratitis	sl. pigment centrally	n	cataract	n	cataract	Yes		
		L	6/9	1 punctate keratitis		n	n	n	No	Yes		
22	24 hr after topical DEC	R	6/6	(visual acuity test only; left without remainder of ophthalmologic examination)								
		L	6/6									
23	48 hr after oral DEC	R	6/6	1 mf--inferior temporal	n	min. stroma	n	n	No	Yes		
		L	6/6	4 mf--scattered	1 dead mf	" "	n	n	No	Yes		

** Abbreviations: mf = microfilaria(e); n = normal; FB = foreign body; top. = topical; ker. = keratitis; sl. = slight

*** L anterior chamber: small semi-transparent white keratitic precipitates

**** L fundus: chorio-retinitis; pigment change and loss; typical of ocular onchocerciasis

R, L fundus: diffuse depigmentation of posterior pole; small round light, dirty-yellow areas of depigmentation resembling drusen but not as yellow as usually seen

TABLE 5. (continued--2 additional patients at Barkaimai, not in Table 1)

Patient No.*	Age Sex	Notes	Eye	Visual Acuity [@]	Cornea**	Anterior Chamber	Iris	Lens	Fundus	Vision Loss	Ocular Oncho.
27	36/M	(a)	R,L	(loss of vision, 7 years ago; patient had some difficulty with L leg and sid of body, at approximately the same time)							
			R	LP \bar{S} P	n	n	n	n	discs: glaucoma ^b ; No		
			L	LP \bar{S} P	n	n	n	cup--optic atrophy ^y	No		
28	65/M	(c)	R,L	(loss of vision, 20 years ago--from cataracts)							
			R	HM	n	n	stromal atrophy (d)	cata- ract	unable to visualize	cataract	No
			L	NLP	n	n	stromal atrophy (e)	cata- ract	unable to visualize	cataract	No

@ Abbreviations: LP \bar{S} P = light penetration without perception; HM = hypermetropia; NLP = no light perception

- (a) Patient No. 27 had eye examination only--not examined for nodules, dermatitis, lymphadenopathy; not accessioned at AFIP; not included in Table 1; Dr. Ganley's patient "D".
- (b) R, L optic discs of Patient No. 27 are pale white, with total excavation, no rim, nasal displacement. The intraocular pressure was not taken, but the appearance of the discs was compatible with glaucoma and not primary optic atrophy
- (c) Patient No. 28 had eye examination only; not examined for nodules, dermatitis, lymphadenopathy; not accessioned at AFIP; not included in Table 1; Dr. Ganley's patient "E".
- (d) large areas of clefts in R iris with lens clearly visible through clefts; similar to essential iris atrophy.
- (e) atrophy of L iris was visible only by retroillumination.

TABLE 6. Ophthalmologic Findings for Onchocerciasis Patients at Lugbeeye

Patient No.*	Time After Treatment	Eye	Visual Acuity	Cornea**	Anterior	Iris	Lens	Fundus	Vision	Ocular
					Chamber				Loss	Oncho.
31	24 hr after topical DEC	R	6/6	numerous punctate keratitis	n	Stroma-- loss of frill	n	n	No	Yes
		L	6/6	" " "	many		n	n	No	Yes
34	24 hr after topical-DEC	R	6/12	more than 25 punctate keratitis, minimal peri., nasal & temporal infiltrates.	1+ Flare	Stroma-- loss of frill; post. syn.	n	onchocercal chorio-retinitis ***	Yes	Yes
		L	6/9	ca 15 mf; 25 punctate keratitis, min. peri., nasal & temporal infiltrates	keratitic ppt's, inferiorly		Stroma-- loss of frill	n	onchocercal chorio-retinitis ***	No
36	48 hr. after topical DEC	R	6/6	4 punctate keratitis	1 mf	n	n	n	No	Yes
		L	6/6	3 " "	2 mf	n	n	n	No	Yes
37	24 hr after topical DEC	R	6/6	n	n	n	n	n	No	No
		L	6/6	n	n	n	n	n	No	No
38	24 hr after topical DEC	R	6/6	n	n	n	n	n	No	No
		L	6/6	n	n	n	n	n	No	No
40	24 hr after topical DEC	R	6/6	n	n	n	n	n	No	No
		L	6/6	n	n	n	n	n	No	No
41	24 hr after topical DEC	R	6/6	n	1 mf	n	n	n	No	Yes
		L	6/6	n	1 mf	n	n	n	No	Yes
42	24 hr after topical DEC	R	6/6	n	n	n	traumatic cataract	n	No	No
		L	6/6	n	n	n	n	n	No	No
43	24 hr after topical DEC	R	6/6	n	n	n	n	n	No	No
		L	6/6	ca 20 punctate keratitis	n	n	n	n	No	Yes
44	24 hr after topical DEC	R	6/6	n	n	n	n	n	No	No
		L	6/6	n	n	n	n	n	No	No

* 32,33,35, (no ophthalmologic examinations)

TABLE 6. (continued)

Patient No*	Time After Treatment	Eye	Visual Acuity [@]	Cornea**	Anterior Chamber	Iris	Lens	Fundus	Vision Loss	Ocular Oncho.
46	No Rx	R	(2-year history of decreasing visual acuity; no evidence of onchocerciasis)							
		L	6/24 no light penetration	diffuse edema " "	n n	n n	n n	large glaucomatous cups	No No	
47	Before Treatment	R	0.5/24	n	n	n	cataract	unable to visualize	cata-	No
		L	hypermetropia	n	n	n	"	"	racts	No
48	No Rx	R	0.5/24	n	n	n	n	macular depigmentation	Probably	
		L	6/9	n	n	n	n	n	No	No
50	Before Treatment	R	(7-year history of eye trouble; not blind, but eyes hurt and tears)							
		L	6/6	1 punctate keratitis	1 mf	n	n	n	n	No
51	Before Treatment	R	6/9	n	n	n	n	n	No	No
		L	6/6	n	n	n	n	n	No	No
52	Before Treatment	R	(3-1/2 year history of blindness, L & R; sufficient light penetration for slit lamp exam.)							
		L	FC	n	1+ Flare, Stroma	early atrophy	onchocercal	chorio-ret. retinitis (proliferative type)		
53	Before Treatment	R	(struck in L eye, 4-5 years ago; may have been infected)							
		L	6/18	central stromal scar; not too dense	n	n	n	n	n	No
54	Before Treatment	R	6/6	1 punctate keratitis	n	min. Stroma	n	greyish mottling & drusen	No	Yes
		L	6/6	occasional punctate keratitis	1 mf	" "	n	slight depigmentation	No	Yes

TABLE 6. (continued)

Patient No.*	Time After Treatment	Eye	Visual Acuity	Cornea**	Anterior Chamber	Iris	Lens	Fundus	Vision Loss	Ocular Oncho.
59	20 hr after Intradermal DEC	R	(struck in right eye by a stick, as a small boy) no light perception	occasional mf & punctate keratitis	n	#	lens remnants & cysute	optic atrophy of disc; trauma chorio.-- pigment loss, etc.	yes	yes
		L	6/6	occasional mf & punctate keratitis	n	n	n	n	n	Yes
61	20 hr after Intradermal DEC	R	(small round scar on cornea of right eye; happened when very small; circumstances unknown) 6/6	8-10 punctate keratitis; + scar	n	n	n	n	n	Yes
		L	6/6	1-2 punctate keratitis	1 mf	n	n	chorio.- heavy pigment	n	Yes
63	20 hr after Intradermal DEC	R	6/6	n	3 mf	n	n	chorio.- diffuse depigmt'n	n	Yes
		L	6/6	n	n	n	n	chorio,- diffuse depigmt'n	n	No

* 55,56,57, (no ophthalmologic examinations)
58,60,62,
64,65

** Abbreviations: mf = microfilaria(e); n = normal; peri. = perilimbal infiltrate; temp. = temporal infiltrate; pos^t. syn. = posterior synechia;

*** For patient No. 34: couldn't visualize fundus well because of miotic pupil and extensive posterior synechia; couldn't visualize disc or vessels of R eye; chorio.--scattered diffuse depigmentation, both R & L (R>L).

Iris of R eye of patient No. 59: superior iridolysis.

TABLE 6. (continued--9 additional patients at Lugbeyee, not in Table 3)

Patient No.*	Age Sex	Notes	Eye	Visual Acuity [@]	Cornea**	Anterior Chamber	Iris	Lens	Fundus	Vision Loss	Ocular Oncho.
66	50/F	(a)	R	5/36	n	n	n	n	maeular depigmentation (probably oncho.)		Yes
			L	6/12	n	n	n			Yes	
67	60/F	(b)	R	FC	n	n	n	{ cata- racts	not visualized	cata- racts	No
			L	5/36	n	n				No	
68	65/F		R	NLP						cause not determined	No
			L	NLP							No
69	27/M		R	FC/20 ft					glaucoma		No
			L	NLP					glaucoma		No
70	50/F		R	LP				{ cata- racts	not visualized	cata- racts	No
			L	LP						No	
71	30/M		R	FC						cause not determined	No
			L	HM							No
72	68/F		R	HM				{ cata- racts		cata- racts	No
			L	LP						No	
73	65/?		R	HM				{ cata- racts		cata- racts	No
			L	20/400						No	
74	60/?		R	LP	Corneal scar--probably secondary to infection					corneal scar	No
			L	6/6						No	

@ Abbreviations: FC = finger counting; LP = light perception; NLP = no light perception; HM = hypermetropia
 ** n = normal

(a) Ganley's patient A; not accessioned at AFIP

(b) Ganley's patient B' " " " "

TABLE 7. Frequencies of ocular onchocerciasis by age distribution, at Barkaimai, Luqbevee and Mawua

Age Range (years)	Number of Patients	Number (percent) of patients in this age range with:				Ocular Onchocerciasis
		Punctate Keratitis	Microfilariae in Anterior Chamber	Onchocercal Chorioretinitis	Optic Atrophy	
a. among 18 inhabitants of Barkaimai given ophthalmic examinations (Table 5):						
20-39	4	2 (50%)	1 (25%)			2 (50%)
40-59	7	5 (71%)	2 (29%)	1 (14%)		5 (71%)
60+	7	2 (29%)	1 (14%)	1 (14%)		3 (43%)
TOTAL	18	9 (50%)	4 (22%)	2 (11%)		10 (56%)
b. among 23 inhabitants of Luqbevee given ophthalmic examinations (Table 6):						
20-39	7	3 (43%)	3 (43%)	1 (14%)		3 (43%)
40-59	9	4 (44%)	4 (44%)	2 (22%)		6 (67%)
60+	7	1 (14%)	2 (29%)	4 (57%)		4 (57%)
TOTAL	23	8 (35%)	9 (39%)	7 (30%)		13 (57%)
c. among 41 inhabitants of Barkaimai and Luqbevee combined given ophthalmic examinations (a + b):						
20-39	11	5 (45%)	4 (36%)	1 (9%)		5 (45%)
40-59	16	9 (56%)	6 (38%)	3 (19%)		11 (69%)
60+	14	3 (21%)	3 (21%)	5 (36%)		7 (50%)
TOTAL	41	17 (41%)	13 (32%)	9 (22%)		23 (56%)
d. among 76 inhabitants of Mawua given ophthalmic examinations:						
0-19	M 5	1 (20%)				1 (20%)
	F 17	7 (41%)	4 (24%)			8 (47%)
	M+F 22	8 (37%)	4 (18%)			9 (41%)
20-39	M 13	4 (31%)	6 (46%)	2 (15%)		9 (69%)
	F 7	3 (43%)	4 (57%)			4 (57%)
	M+F 20	7 (35%)	10 (50%)	2 (10%)		13 (65%)
40-59	M 13	7 (68%)	10 (77%)	4 (31%)	1 (8%)	12 (92%)
	F 6		1 (17%)	2 (33%)		2 (33%)
	M+F 19	7 (37%)	11 (58%)	6 (32%)	1 (5%)	14 (74%)
60+	M 9	3 (33%)	7 (78%)	6 (67%)		7 (78%)
	F 6	2 (33%)	3 (50%)	2 (33%)		4 (67%)
	M+F 15	5 (33%)	10 (67%)	8 (53%)		11 (73%)
TOTAL	M+F 76	27 (36%)	35 (46%)	16 (21%)	1 (1%)	47 (62%)

TABLE 8. Comparisons of age and sex distributions in Mawua, of total village and patients given eye examinations

Age Range (years)	a. <u>of 293 inhabitants of Mawua (total village)*</u>						b. <u>of 76 inhabitants of Mawua given eye examinations**</u>					
	<u>Number of villagers in this category</u>			<u>Percent of population in this category***</u>			<u>Number (percent) of villagers in category given eye examinations</u>			<u>Percent of examined popul'n in category***</u>		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 9	44	37	81	15%	13%	28%	3 (7%)	4 (11%)	7 (9%)	4%	5%	9%
10 - 19	22	34	56	7%	12%	19%	2 (9%)	13 (38%)	15 (27%)	3%	17%	20%
20 - 29	20	24	44	7%	8%	15%	6 (30%)	3 (12%)	9 (20%)	8%	4%	12%
30 - 39	11	21	32	4%	7%	11%	7 (64%)	4 (19%)	11 (34%)	9%	5%	14%
40 - 49	15	8	23	5%	3%	8%	7 (47%)	2 (25%)	9 (35%)	9%	3%	12%
50 - 59	19	16	35	7%	5%	12%	6 (32%)	4 (25%)	10 (29%)	8%	5%	13%
60 +	16	6	22	5%	2%	7%	9 (56%)	6 (100%)	15 (68%)	12%	8%	20%
TOTAL	147	146	293	50%	50%	100%	40 (27%)	36 (25%)	76 (26%)	53%	47%	100%

* Data on enumeration of village of Mawua provided by Dr. **Albiez**, Liberia Research Unit of the Tropical Institute Hamburg (see text Section II.I.2).

** Data on villagers of Mawua given slit lamp eye examinations by Dr. Ganley, 14-18 December 1978.

*** Percentages are rounded, and may not add up to 100%.

TABLE 9. Visual acuity levels by age for individual eyes, among inhabitants of Barkaimai, Luqbeyee and Mawua

Age Range (years)	Number of Eyes	Level of Visual Acuity*							
		6/6 - 6/12		6/18 - 6/36		6/60 - 3/60		1/60 - NLP	
		No. of Eyes	% of Eyes	No. of Eyes	% of Eyes	No. of Eyes	% of Eyes	No. of Eyes	% of Eyes
a. <u>among 18 inhabitants of Barkaimai (Table 5):</u>									
20-39	8	6	75%					2	25%
40-59	14	11	79%	3	21%				
60+	<u>14</u>	<u>11</u>	79%	—				<u>3</u>	21%
TOTAL	36	28	78%	3	8%			5	14%
b. <u>among 30 inhabitants of Luqbeyee (Table 6):</u>									
20-39	18	12	56%	1	6%	1	6%	4	22%
40-59	20	17	85%			1	5%	2	10%
60+	<u>22</u>	<u>6</u>	32%	<u>1</u>	5%	<u>2</u>	9%	<u>13</u>	59%
TOTAL	60	35	58%	2	3%	4	7%	19	32%
c. <u>among 48 inhabitants of Barkaimai & Luqbeyee combined (a + b)</u>									
20-39	26	18	69%	1	4%	1	4%	6	23%
40-59	34	28	82%	3	9%	1	3%	2	6%
60+	<u>36</u>	<u>17</u>	47%	<u>1</u>	3%	<u>2</u>	6%	<u>16</u>	44%
TOTAL	96	63	66%	5	5%	4	4%	24	25%
d. <u>among 23 inhabitants of Barkaimai & Luqbeyee with ocular onchocerciasis:</u>									
20-39	10	10	100%						
40-59	22	18	82%	4	18%				
60+	<u>14</u>	<u>10</u>	71%	—				<u>4</u>	29%
TOTAL	46	38	83%	4	9%			4	9%
e. <u>among 76 inhabitants of Mawua:</u>									
0- 9	14	14	100%						
10-19	30	30	100%						
20-29	18	18	100%						
30-39	22	22	100%						
40-49	18	18	100%						
50-59	20	14	70%	2	10%	2	10%	2	10%
60+	<u>30</u>	<u>22</u>	73%	<u>2</u>	7%	<u>2</u>	7%	<u>4</u>	13%
TOTAL	152	138	91%	4	3%	4	3%	6	4%
f. <u>among 124 inhabitants of Barkaimai, Luqbeyee & Mawua combined (a + b + e):</u>									
TOTAL	248	201	81%	9	4%	8	3%	30	12%

* By "tumbling F" method (see text Section II.I); NLP = no light perception.

TABLE 10. Causes of visual loss, among inhabitants of Barkaimai, Lugbeyee & Mawua:

Cause of Visual Loss	<u>Acuity between 6/18 - 6/36:</u>			<u>Acuity of 6/60 or worse:</u>		
	No. of Eyes	No. of Patients	Patient No.*	No. of Eyes	No. of Patients	Patient No.*
<u>a. among 18 inhabitants of Barkaimai given an ophthalmic examination:</u>						
Onchocerciasis	2	1	16			
Cataract	1	1	21	2	1	28
Glaucoma				2	1	27
Small pox	—	—		<u>1</u>	<u>1</u>	15
TOTAL	3	2		5	3	
<u>b. among 43 inhabitants of Lugbeyee given an ophthalmic examination:</u>						
Onchocerciasis				4	3	48,52,66
Cataract				10	5	47,67,70,72,73
Glaucoma	1	1	46	3	2	46,69
Corneal scar	1	1	68	1	1	74
Trauma				1	1	59
Unknown	—	—		<u>4</u>	<u>2</u>	68,71
TOTAL	2	2		23	14	
<u>c. among 61 inhabitants of Barkaimai & Lugbeyee given an eye examination (a + b):</u>						
Onchocerciasis	2	1		4	3	
Cataract	1	1		12	6	
Glaucoma	1	1		5	3	
Small pox				1	1	
Corneal scar	1	1		1	1	
Trauma				1	1	
Unknown	—	—		<u>4</u>	<u>2</u>	
TOTAL	5	4		28	17	
<u>d. among 76 inhabitants of Mawua given an ophthalmic examination:</u>						
Onchocerciasis	1	1	75	3	2	81,82
Cataract	3	2	77,80	2	2	77,78
Glaucoma				2	1	83
Traumatic cataract				1	1	79
Uncorrected aphakia	—	—		<u>2</u>	<u>1</u>	76
TOTAL	4	3		10	7	
<u>e. among 137 inhabitants of Barkaimai, Lugbeyee & Mawua given eye exams (a + b + c):</u>						
Onchocerciasis	3	2		7	5	
Cataract	4	3		14	8	
Glaucoma	1	1		7	4	
Traumatic cataract				1	1	
Uncorrected aphakia				2	1	
Small pox				1	1	
Corneal scar	1	1		1	1	
Trauma				1	1	
Unknown	—	—		<u>4</u>	<u>2</u>	
TOTAL	9	7		38	24	

* See Table 11 for acuity levels and cause of decrease in visual acuity.

TABLE 11. Visual acuity of 6/18 or worse by cause of decrease, among inhabitants of Barkaimai, Luqbeyee & Mawua

Patient No.*	Age Sex	Eye	Visual Acuity ^a	Cause of decrease in visual acuity
<u>a. among 5 inhabitants of Barkaimai:</u>				
15	80/M	R L	NLP 6/6	Corneal scar--probably smallpox
16	45/F	R L	6/24 6/18	Corneal edema--probably onchocerciasis " " " "
21	55/F	R L	6/24 6/9	Cataract
27	36/M	R L	LP LP	Glaucoma Glaucoma
28	65/M	R L	HM NLP	Cataract--unable to visualize fundus Cataract-- " " " "
<u>b. among 15 inhabitants of Luqbeyee:</u>				
46	28/M	R L	6/24 NLP	Glaucoma Glaucoma
47	65/M	R L	.5/24 HM	Cataract--fundus not visualized Cataract-- " " "
48	62/M	R L	.5/24 6/9	Macular depigmentation--probably onchocerciasis
52	60/M	R L	FC LP	Chorioretinitis--onchocerciasis Chorioretinitis-- "
53	60/M	R L	6/9 6/18	Corneal scar--probably secondary to infection
59	60/M	R L	NLP 6/6	Atrophic disc--secondary to trauma
66	50/F	R L	5/36 6/12	Macular depigmentation--probably onchocerciasis Macular depigmentation-- " "
67	60/F	R L	FC 5/36	Cataract--fundus not visualized Cataract--fundus not visualized
69	27/M	R L	FC/20 ft NLP	Glaucoma Glaucoma
70	50/F	R L	LP LP	Cataract--fundus not visualized " " " "
71	30/M	R L	FC HM	Cause not determined " " "
72	68/F	R L	HM LP	Cataract Cataract
73	65/?	R L	HM 20/400	Cataract Cataract
74	60/?	R L	LP 6/6	Corneal scar--probably secondary to infection

TABLE 11. (continued)

Patient No.*	Age Sex	Eye	Visual Acuity	Cause of decrease in visual acuity
c. among 9 inhabitants of Mawua:				
75	58/M	R	6/9	Optic atrophy--probably onchocerciasis
		L	6/18	Optic atrophy-- " "
76	55/M	R	CF/1 meter	Uncorrected aphakia
		L	6/60	" "
77	56/F	R	6/18	Cataract
		L	6/60	Cataract
78	56/F	R	6/12	Cataract
		L	Hand motion	"
79	60/M	R	NLP	Traumatic cataract
		L	6/6	
80	67/F	R	6/18	Cataract
		L	6/18	Cataract
81	61/F	R	6/60	Macular depigmentation--probably onchocerciasis
		L	6/60	" " " "
82	70/M	R	6/12	Macular depigmentation--probably onchocerciasis
		L	CF/1 meter	" " " "
83	70/M	R	NLP	Glaucoma
		L	NLP	Glaucoma

* Data on skin snips, dermatitis, nodules and lymphadenopathy are given in Table 1 for patients 15-21; Table 3 for patients No. 46-59. More complete data on ophthalmic examinations are given in Table 5 for patients No. 15-28, and in Table 6 for patients No. 46-66.

@ NLP = no light perception; LP = light perception; HM = hypermetropia; FC = finger counting.

TABLE 12. Comparisons of microfilaria and nodule carriers in Mawua, of total village and patients given eye exams

Age Range (years)	a. 293 inhabitants of Mawua (total village)*					b. 76 inhabitants of Mawua given eye examinations**				
	Number of Villagers	No. (%) of Microfilarial Carriers	Mean mf/mg: Skin Snips of Hips	No. (%) of Nodule Carriers	Nodules per Carrier	No. of Villagers Examined	No. (%) of Microfilarial Carriers	Mean mf/mg: Skin Snips of Hips	No. (%) of Nodule Carriers	Nodules per Carrier
0 - 9	81	19 (24%)	3.6	4 (5%)	1.3	7	4 (57%)	1.3	0 (0%)	-
10 - 19	56	42 (75%)	4.3	24 (43%)	2.2	15	9 (75%)	6.9	6 [#] (50%)	2.5
20 - 29	44	39 (89%)	12.2	30 (68%)	3.1	9	7 (88%)	18.3	6 [#] (67%)	1.8
30 - 39	32	31 (97%)	13.7	22 (69%)	4.0	11	11 (100%)	31.7	8 (73%)	4.1
40 - 49	23	23 (100%)	26.7	23 (100%)	5.2	9	7 [#] (100%)	35.2	5 [#] (71%)	2.2
50 - 59	35	35 (100%)	29.5	30 (86%)	6.1	10	8 [#] (100%)	15.8	4 [#] (50%)	1.8
60 +	22	22 (100%)	34.1	19 (86%)	5.7	15	15 (100%)	33.2	11 (73%)	6.1
TOTAL	293	211 (72%)	12.7	152 (52%)	4.3	76	71 [#] (90%)	18.0	40 [#] (59%)	3.6

* Data on microfilarial carriers and nodules in village of Mawua were provided by Dr. Büttner, Liberia Research Unit of the Tropical Institute Hamburg (see text Section II.I.2).

** LRU-TIH Data on microfilarial carriers (skin snips of hips) and nodule carriers for the villagers of Mawua given slit lamp eye examinations by Dr. Ganley, 14-18/ Dec. Microfilarial counts from skin snips of canthi were also taken from some patients, but are not included in this table. A few patients had microfilariae in the canthus but not in the hip.

Data weren't immediately available for a few of the patients given eye examinations; percentages are relative only to the number for whom data were available.

TABLE 13. Xenodiagnostic Evaluations of Three Patients at Barkaimai after 1-3 Topical Applications of DEC.

Patient No.*	No. of Topical Applications of DEC to R leg	No. of Flies Examined		No. of Flies with Microfilariae		Mean No. of Microfilariae in Blood Meal**		No. of Flies with Microfilariae in the Thorax	
		Fed on untreated	Fed on treated	From untreated	From treated	From untreated	From treated	From untreated	From treated
		L leg	R leg	L leg	R leg	L leg	R leg	L leg	R leg
12	2	5	12	2	10	1.50	6.10	1	5
	3	10	9	6	7	4.40	2.33	4	5
13	1	5	11	5	9	12.40	8.86	4	5
	2	8	12	7	6	6.67	4.50	7	4
17	2	5	8	4	6	15.25	14.83	3	5
	3	8	13	5	9	4.25	13.75	5	5

* See Tables 1 & 2 for clinical manifestations of onchocerciasis and treatment schedules.

Patient No.*	**Microfilariae in Pretreatment Skin Snips:		
	L thigh	R thigh	L + R thighs
12	10	3	13
13	5	1	6
17	1	10	11

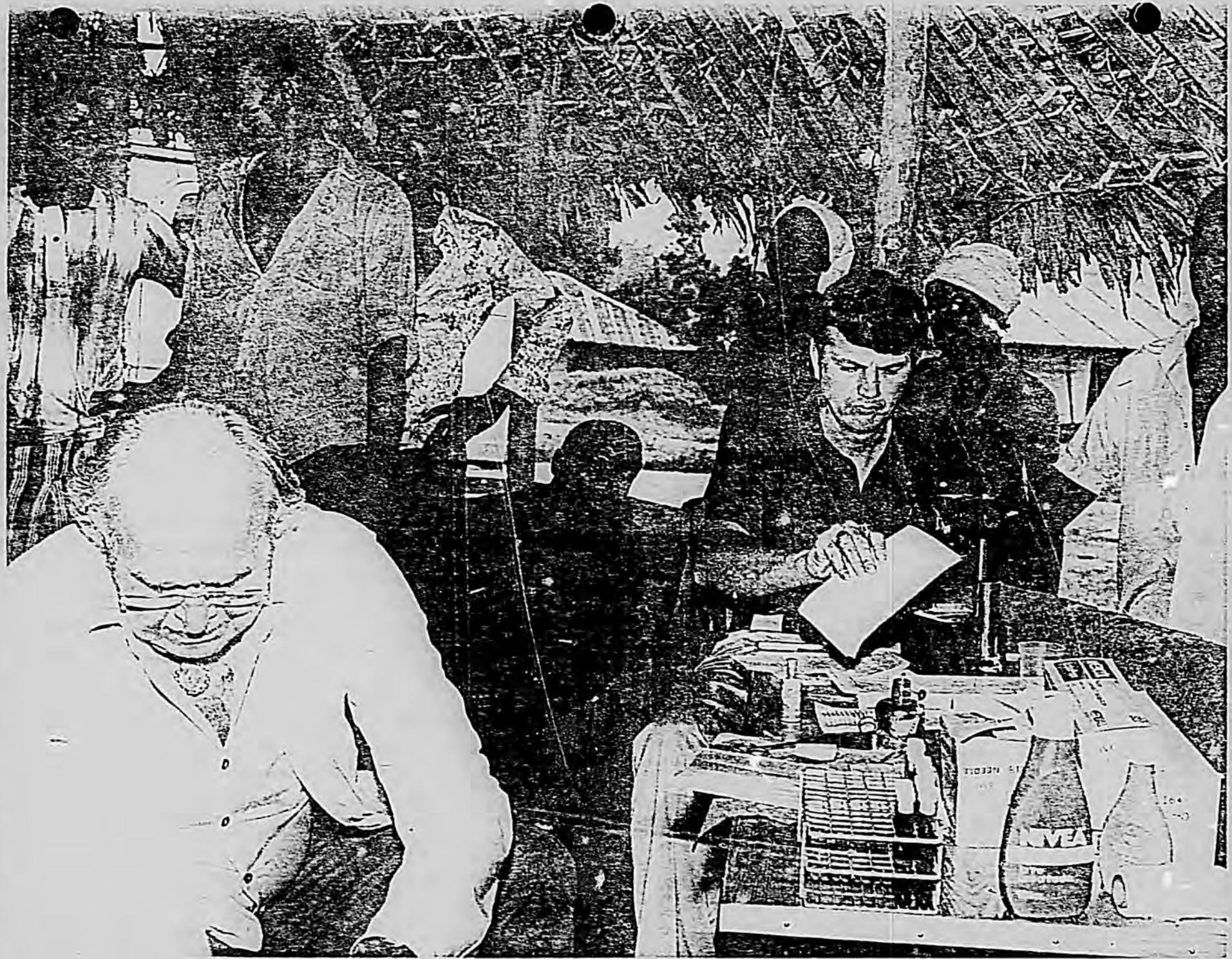
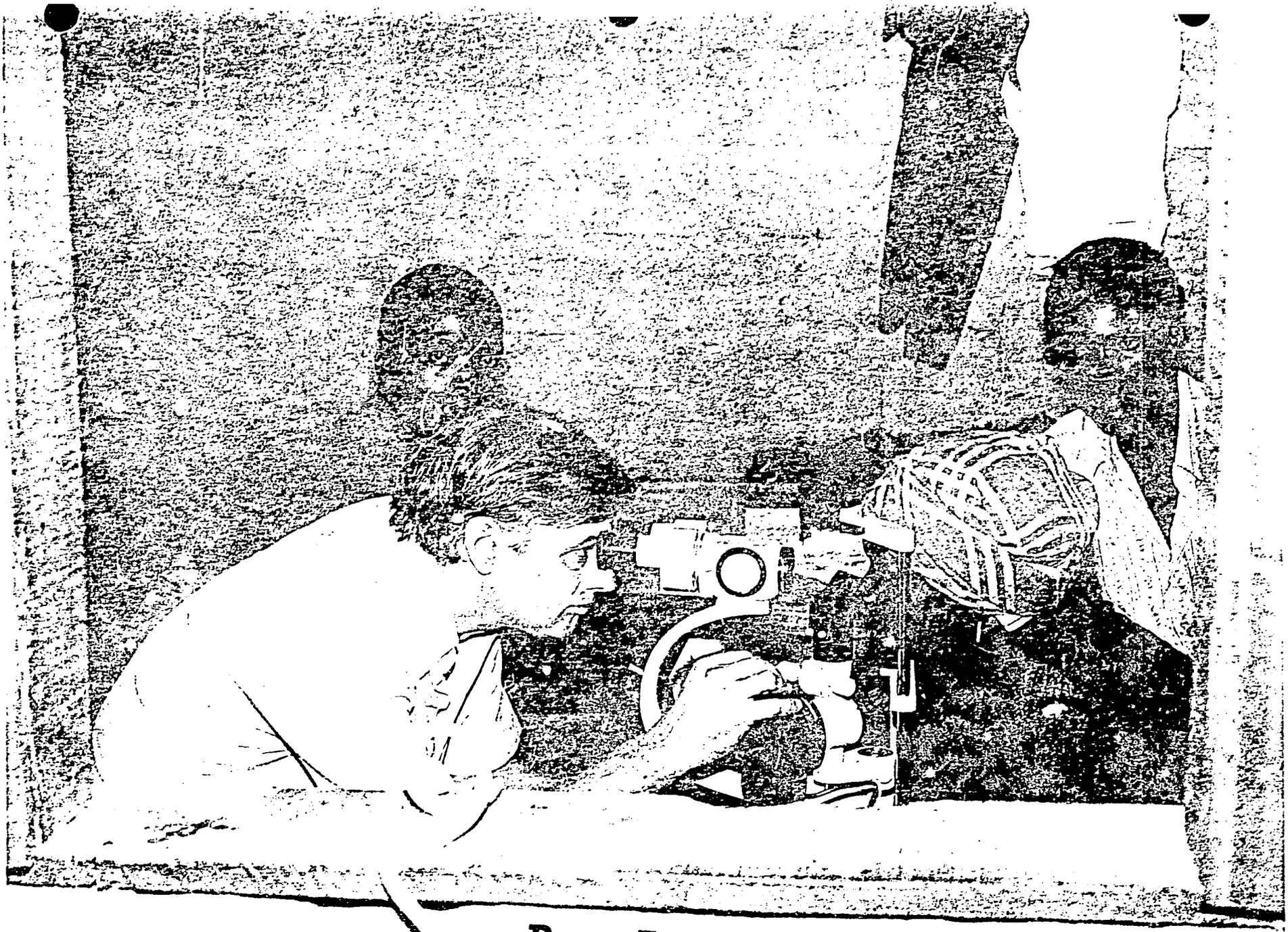


Fig. 1. Dr. Schiller, left foreground, drawing blood; and Dr. Cupp at the dissecting microscope, counting microfilariae in skin snips. YWCA pavilion at Iurbevee, 9 Dec. 1978. AFIP Neg. 78-6474-2.



Best Available Document

Fig. 2. Small room in school master's house, village of Lugbeyee, 9 Dec. 1978. Dr. Ganley is at slit lamp microscope, powered by a portable generator outside. AFIP Neg. 78-6474-3.

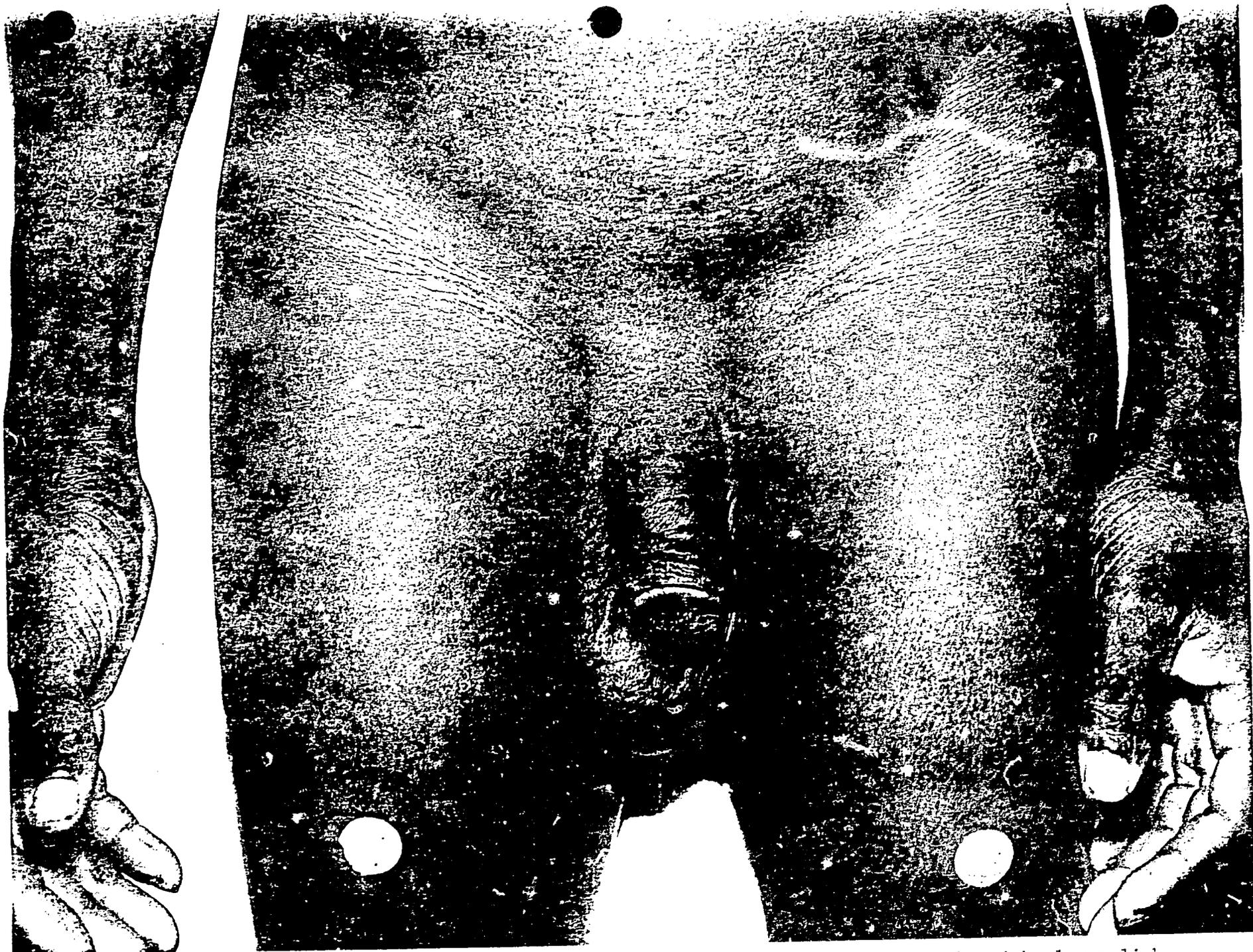


Fig. 3. Patient No. 12, 22 hours after a single topical application of DEC to the right lower limb. The characteristic reaction is present: the right thigh is swollen, warm and edematous and small papules are present. The untreated left thigh shows none of these changes. The bandages on the thighs cover sights of skin snips done the previous day. AFIP Acc. No. 1679385; AFIP Neg. 78-3337.

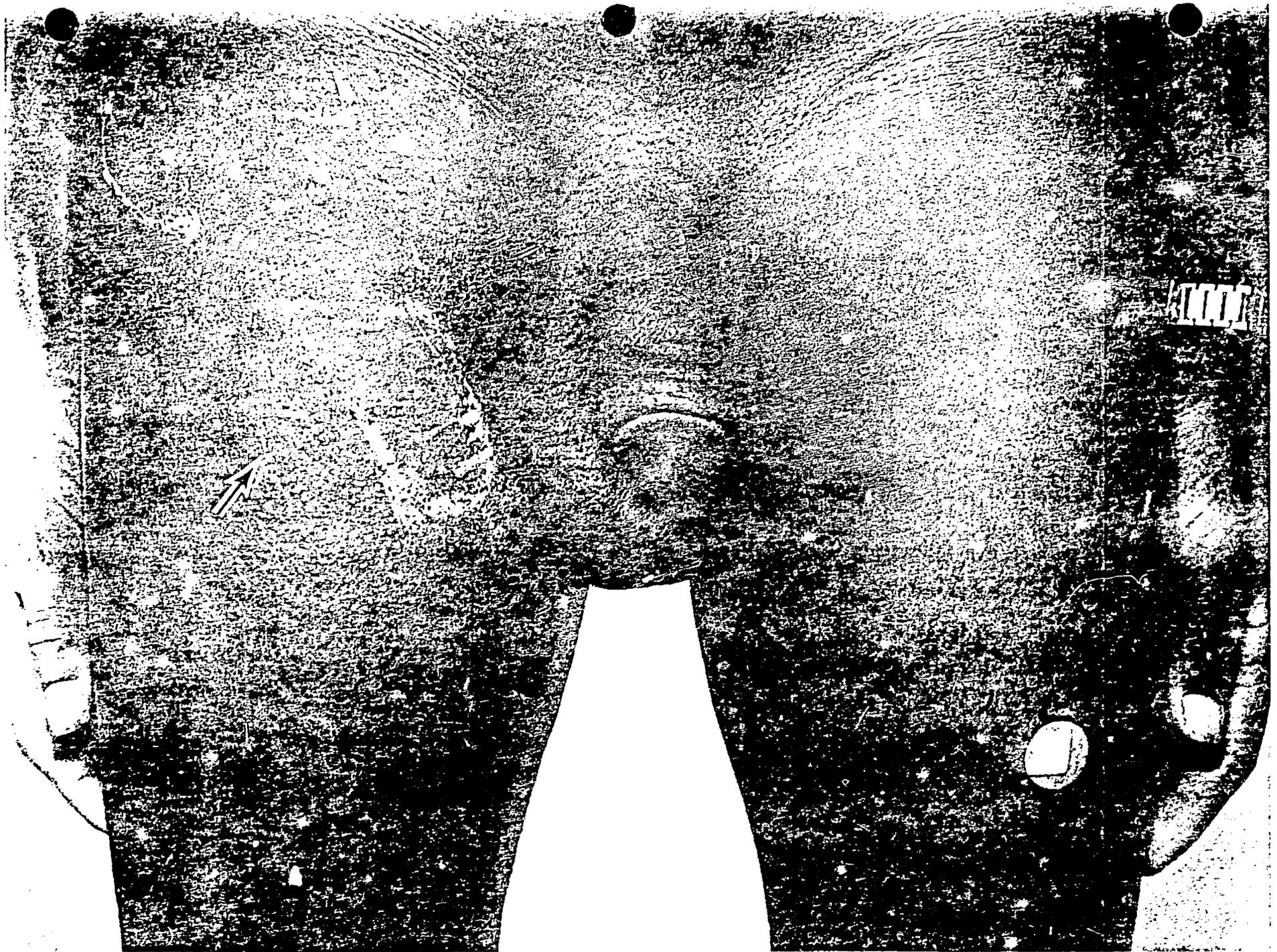


Fig. 4. Patient No. 12 (as in Fig. 3), now at 71 hours--after three daily topical applications of DEC. The papules have become vesicles measuring up to 2 mm across. Also seen is the healing site of 6-mm biopsy specimen 12A taken at 22 hours. Specimen 12B was taken shortly after this picture, through the vesicle indicated by the arrow (see Fig. 12). AFIP Acc. No. 1679385; AFIP Neg. 78-3369.

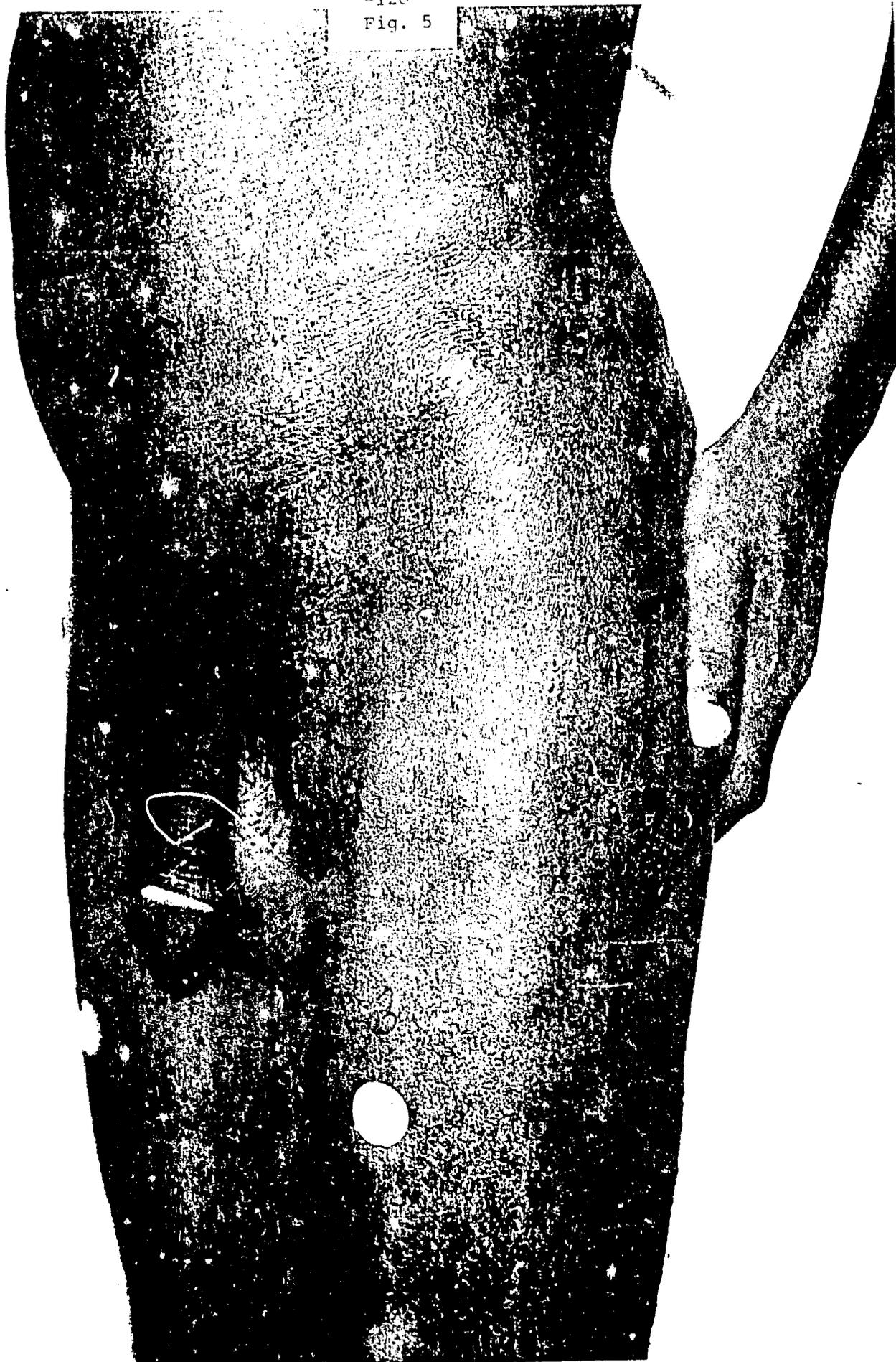


Fig. 5. Patient No. 13 has gale filarienne of the left thigh and hip, unchanged 23 hours after a topical application of DNC to the right leg. A cluster of onchocercal nodules is visible over the left anterior superior iliac spine. Fullness and edema of the skin and subcutaneous tissue over the left femoral node is apparent. This is early hanging groin, a feature of onchocercal lymphadenitis. Bandages cover earlier skin snips. AFIP A. c. No. 1679386; AFIP Neg. 78-3333.

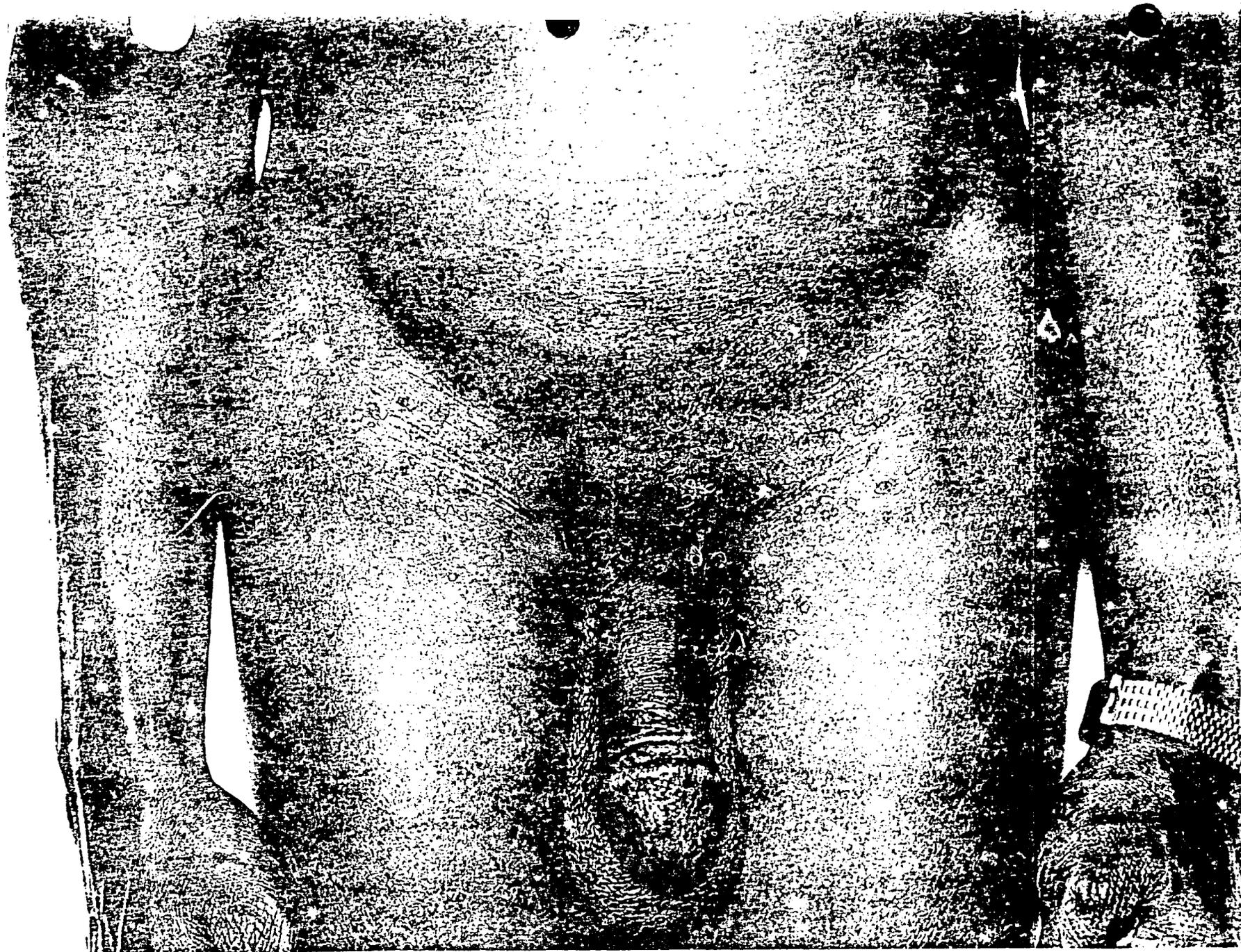
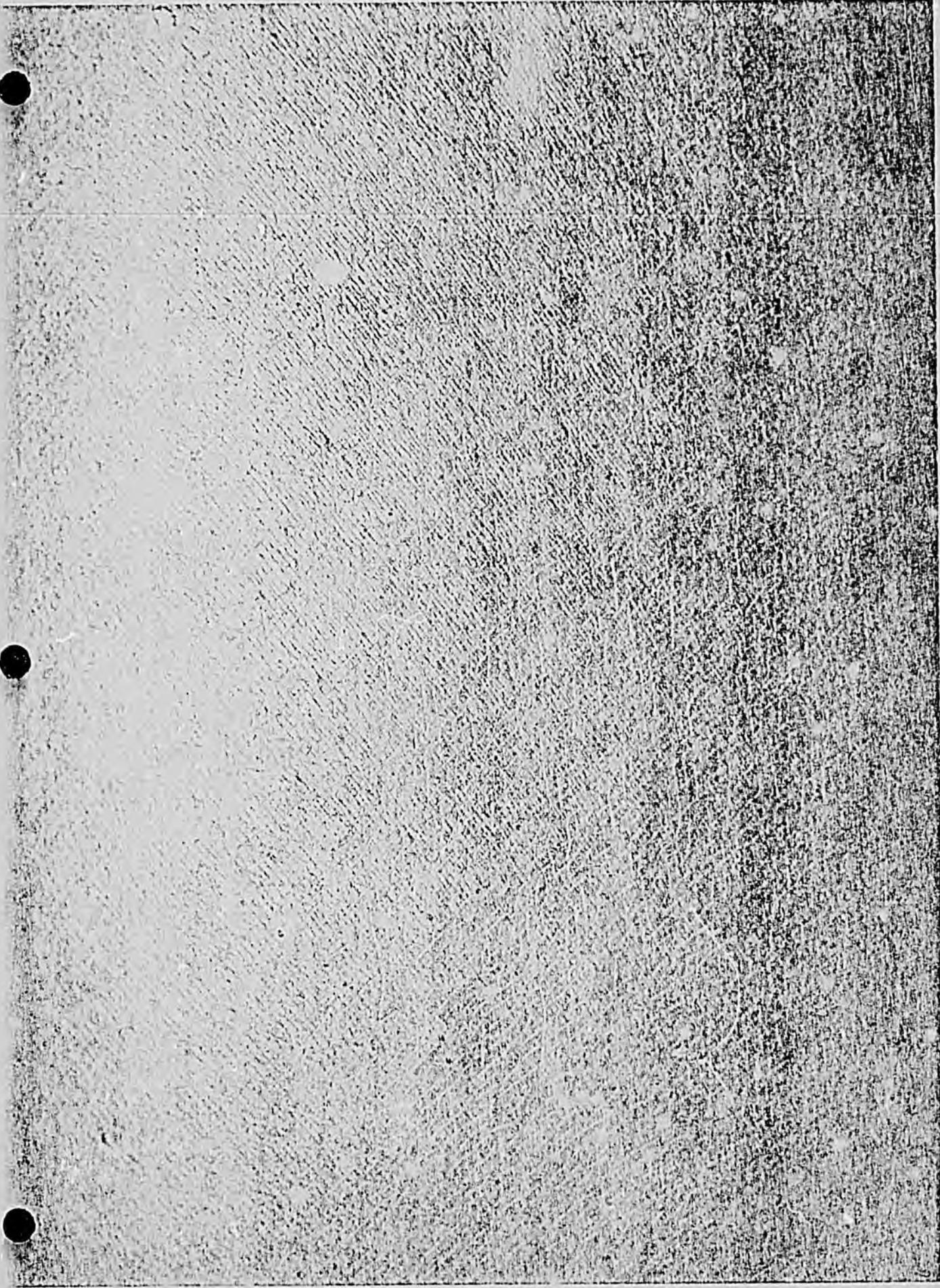


Fig. 6. Patient No. 17, 23 hours after a single topical application of DEC to the right lower limb. There is edema and papular dermatitis, most severe over the anterior right upper thigh. There is some fullness of the soft tissues over the femoral nodes. The wheal from injection of exoantigen is seen on the right arm just beneath the anticubital fossa. Saline without exoantigen was injected into the control circle on the left arm. Bandage is over site of venipuncture. There are nodules over the left and right anterior and superior iliac spines. AFIP Acc. No. 1679390; AFIP Neg. 78-3341.



||||| (mm Scale)

Fig. 7. Patient No. 34, 23 hours after a single topical application of DEC to the right lower limb. Closeup of papules of antero-medial aspect of right thigh. The papules measure up to 3 mm across, and some are capped with small black crusts. AFIP Acc. No. 1679400; AFIP Neg. 78-3372; X2.8 .



-123-
Fig. 3

Fig. 3. Patient No. 35, a 65-year-old woman, 46 hours after a single topical application of DEC to the right leg. She complained of itching over the lateral aspect of the right thigh but excoriations as seen here were most prominent over the buttocks and lower trunk. The skin is wrinkled and scaling--another feature of long-standing chronic onchocercal dermatitis. A cluster of nodules over the sacrum has deviated and divided the upper part of the natal cleft--the so-called "Fuglsang sign." AFIP Acc. No. 1679429; AFIP Neg. 78-3380.

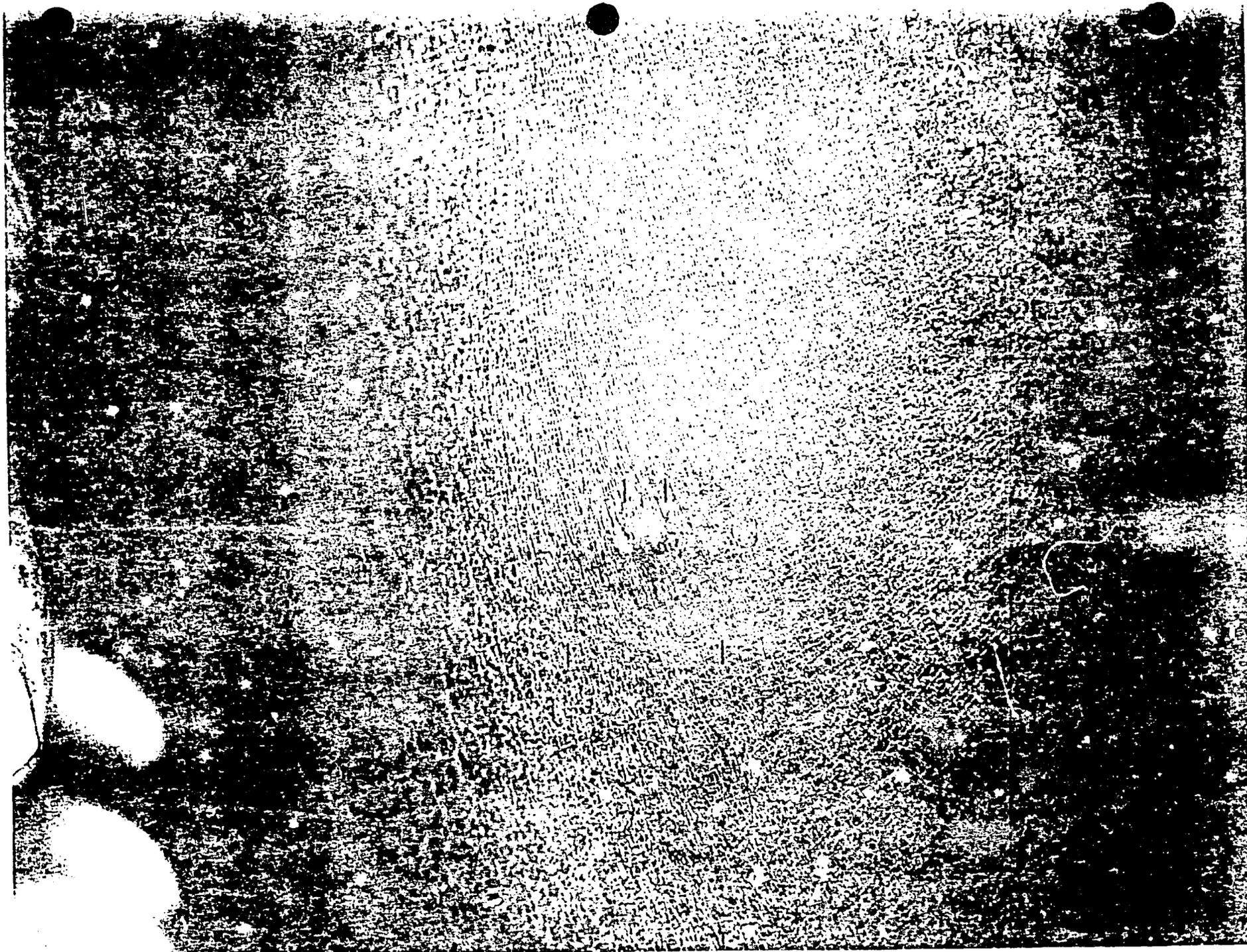
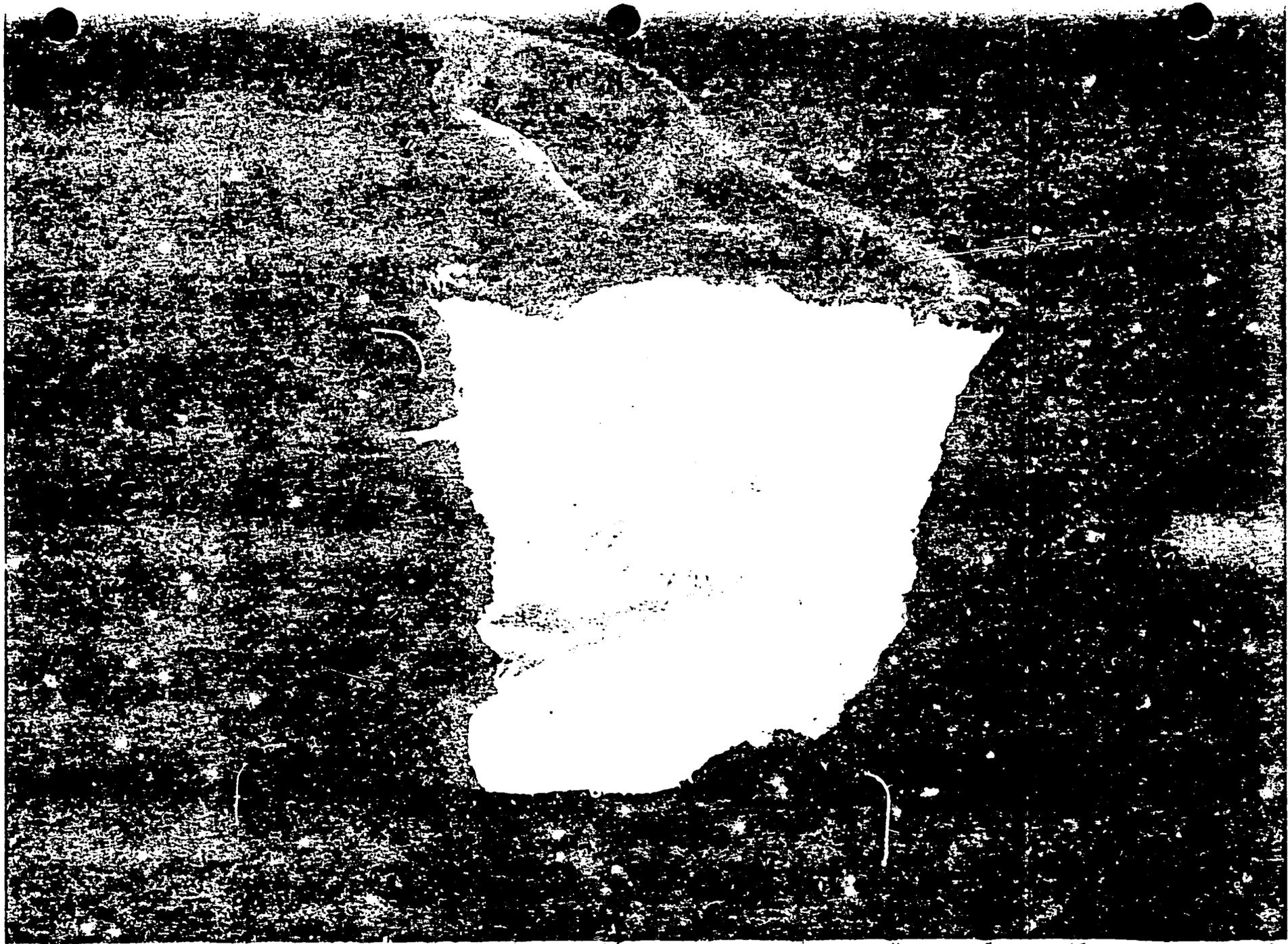


Fig. 9. Patient 59, 20 hours after intradermal injection of DEC (25 mg in 0.25 ml saline) into the right thigh. Within a few minutes of injection the locally produced wheal disappeared; and over the next 20 hours an area of erythema and induration appeared that was 22 mm across, and was capped by a blister approximately 6 mm across. AFIP Acc. No. 1679425; AFIP Neg. 78-8980.

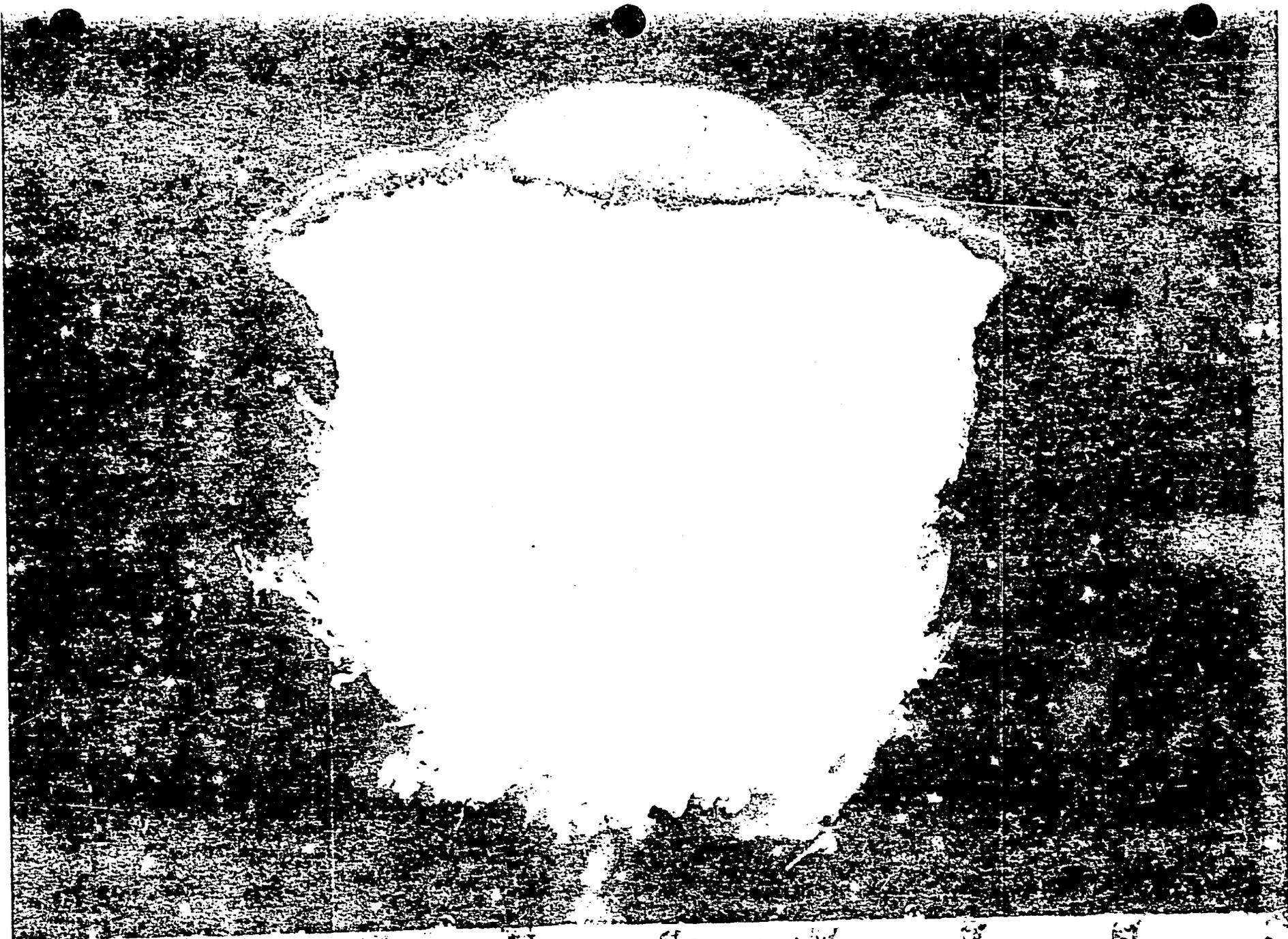


(mm Scale)

Fig. 10. A cross section of biopsy specimen 59A--the blister on the right thigh of patient No. 59, taken 20 hours after intradermal injection of DEC (shown clinically in Fig. 9). The epidermis is lifted off and the fluid has escaped. The dermis is hyperemic (dark area) and the lobulated fat is firm, hyperemic and attached to the underlying dermis. AFIP Acc. No. 1679425; AFIP Neg. 78-8980; X18.



Fig. 11. Patient No. 63, 20 hours after intradermal inoculation of DEC into the left thigh. The patient complained of itching at the sight of inoculation and very slight itching over the remainder of the body. At the injection site there is a vesicle (arrow), about 4 mm across, overlying an area of induration and erythema. Biopsy specimen 63A of this site was taken shortly after this photograph. AFIP Acc. No. 1679429; AFIP Neg. 78-3380.



(mm Scale)

Fig. 12. A cross section of biopsy specimen 12B--the vesicle on the right thigh of patient No. 12, taken at 71 hours, after three daily topical applications of DEC (shown clinically at arrow in Fig. 4). The vesicle is 2 mm across and 0.7 mm deep, and is comprised of fluid, cells and microfilariae (see Figs. 13 & 14). AFIP Acc. No. 1679385; AFIP Neg. 78-8977; X29.

0 0.5 1.0 mm



Fig. 13. Photomicrograph of the intra-epidermal vesicle in specimen 12B (see Figs. 4 & 12). The epidermis is expanded by fluid, cells, fibrin, inflammatory mucin and a few desquamated epidermal cells. There is a microfilaria in the lower part of compartment to the left. There is a diffuse and intense inflammation of the underlying dermis which contains degenerating microfilariae surrounded by inflammatory cells--especially eosinophils and lesser numbers of lymphocytes, plasma cells and histiocytes. AFIP Acc. No. 1679385; AFIP Neg. 78-6504; H&E, X95.

-128-
11.13

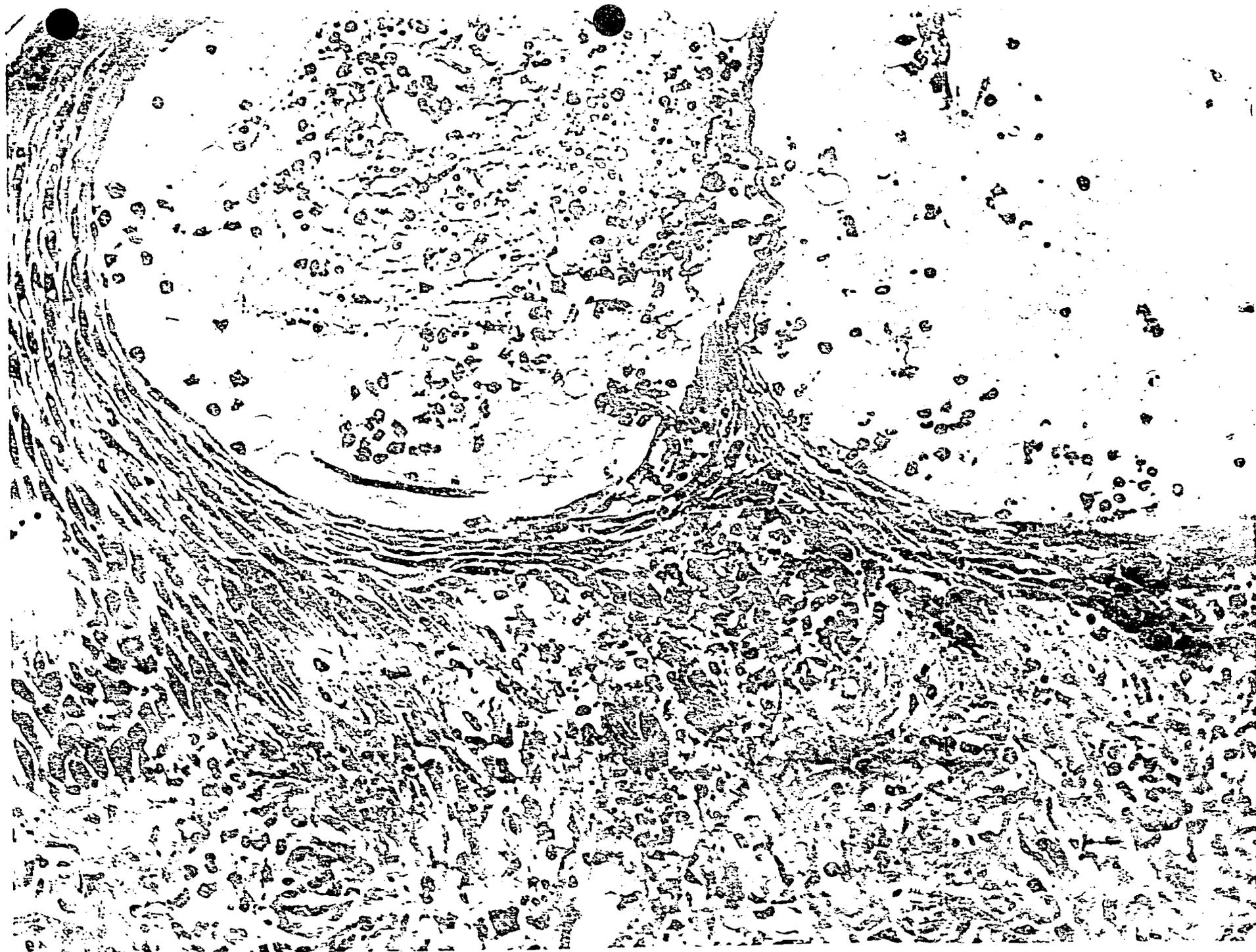


Fig. 14. Specimen 12B--higher magnification of one portion of the photomicrograph shown in Fig. 13. Fibrin and degenerating leucocytes are within the intra-epidermal vesicle and a microfilaria is present near the epidermis in the deep portion of the blister. The dermis is edematous, hyperemic and infiltrated with a variety of inflammatory cells. AFIP Acc. No. 1679385; AFIP Neg. 78-6501; H&E, X390.

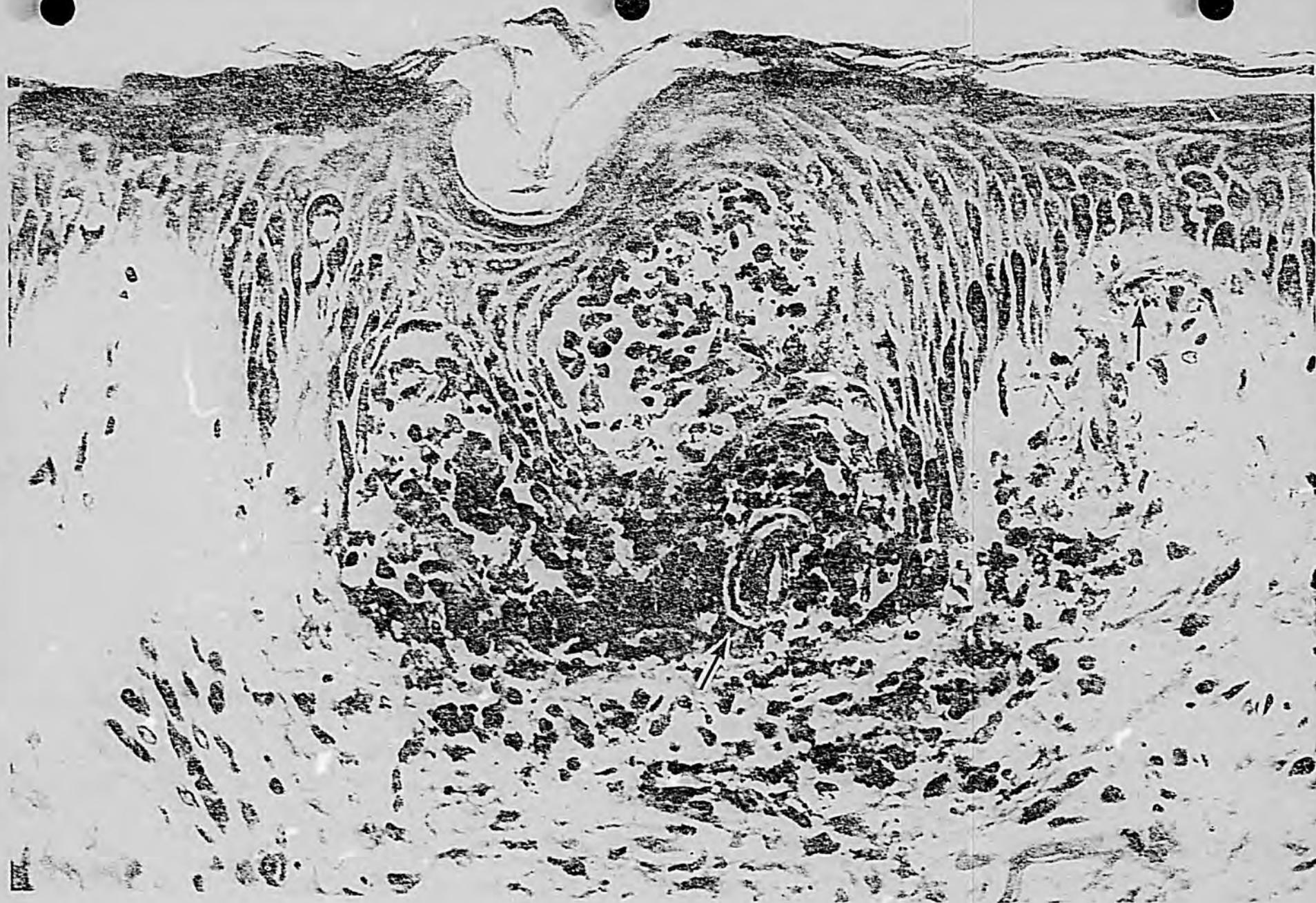


Fig. 15. Photomicrograph of another region of biopsy specimen 12B--away from the large vesicle shown in Figs. 13 & 14. There is a degenerating microfilaria in the lower portion of the epidermis surrounded by degenerating inflammatory cells--mostly eosinophils--and provoking a micro-abscess. The dermal papilla to the right contains a degenerating microfilaria, two sections of which are in this plane of section. It is surrounded by inflammatory cells, some of which are degranulating eosinophils. AFIP Acc. No. 1679385; AFIP Neg. 78-6502; H&E. X165.

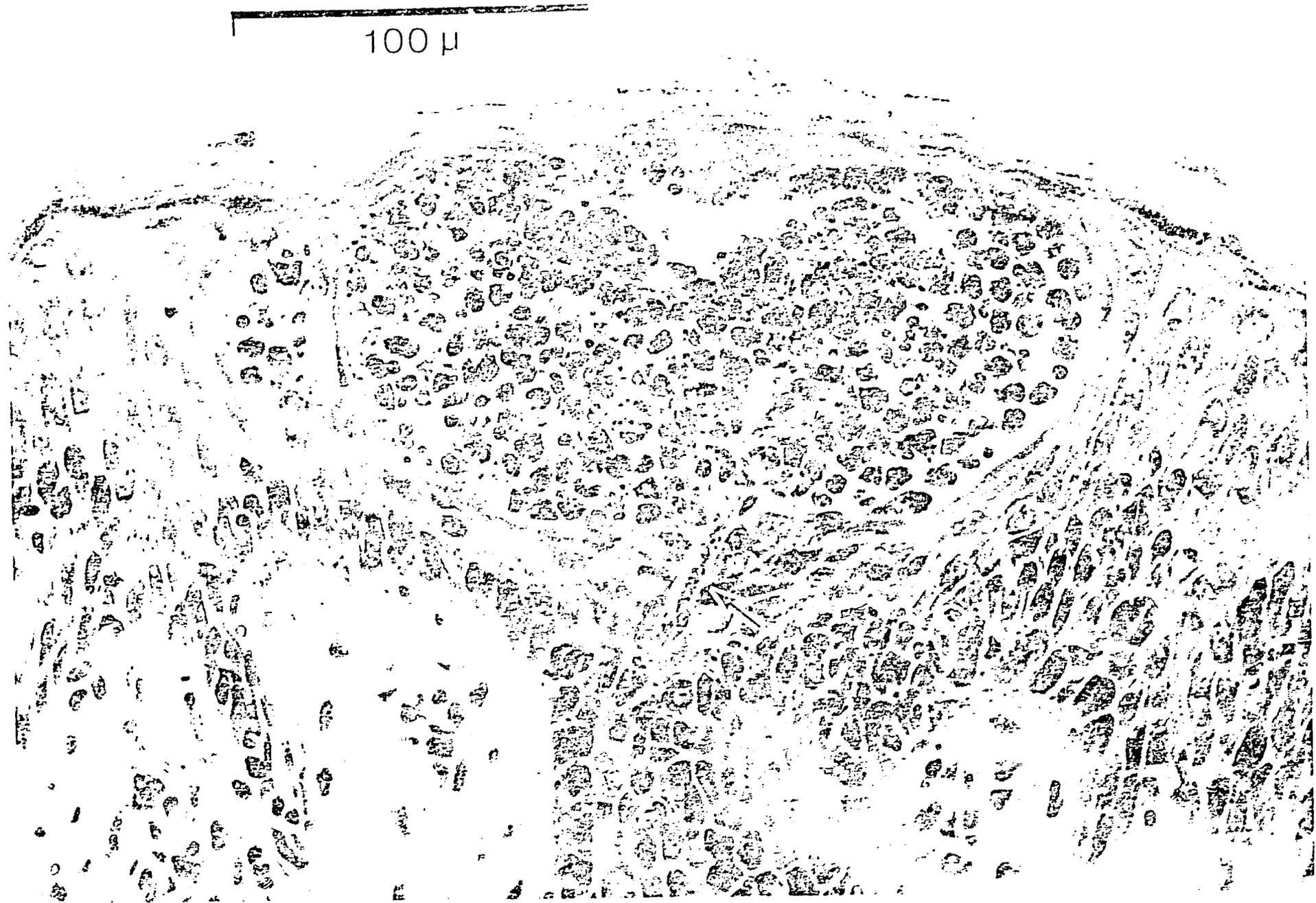


Fig. 16. A portion of biopsy specimen 31A, taken from the right thigh of patient No. 31 at 48 hours-- after two daily topical applications of DEC to the right leg. He developed an urticarial-like papular eruption on the thigh. The specimen contained a large vesicle of 1 mm (not shown) and several smaller vesicles. This one is about 1/4 mm across and 1/10 mm deep, and contains numerous inflammatory cells-- especially eosinophils. There is a microfilaria of Onchocerca volvulus partially in the epidermis and partially in the intra-epidermal abscess. AFIP Acc. No. 1679397; AFIP Neg. 78-6503; H&E, X670.

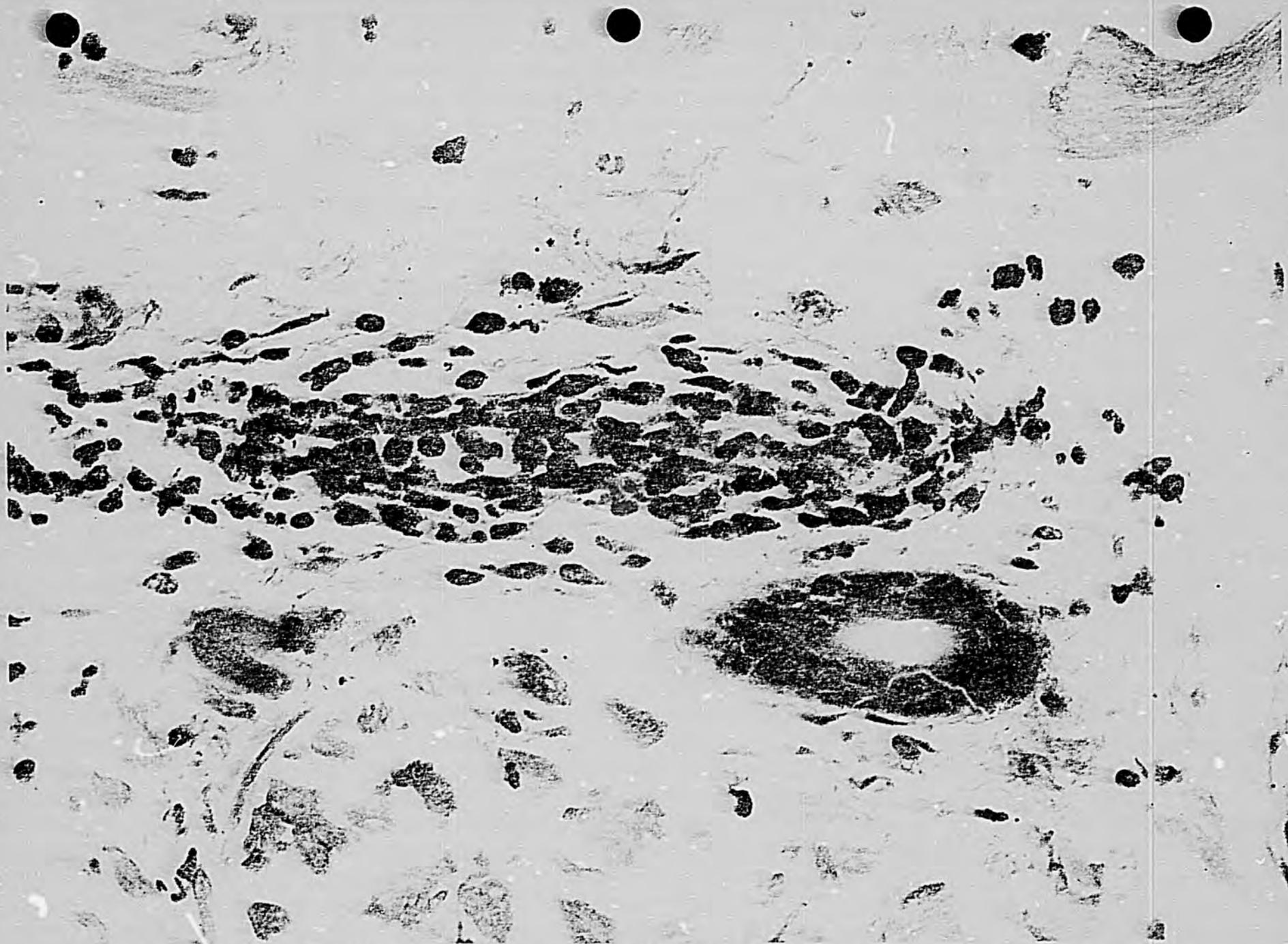


Fig. 17. Biopsy specimen 19A, through a 18 x 20 mm wheal on the right arm that developed in the skin test of patient No. 19. The specimen was taken 50 minutes after injection of a saline solution of microfilarial exoantigen (prepared from in vitro culture of O. volvulus microfilariae). There is edema and hyperemia of the dermis and an infiltration of inflammatory cells--mainly eosinophils--in and around the small vessels of the mid-dermis. AFIP Acc. No. 1679391; AFIP Neg. 78-6503; Giemsa, X740.



Fig. 18. Black fly site #4: upper St. Paul River near the bridge from the Tolbert Farm (Dong Co.) to Beyanstown (Lofa Co.); see Map 4. Oncho. Team visited this site while enroute to and from Voinjama, 2 & 8 December 1978. The water course is wide and poorly shaded--characteristic of breeding sites of Simulium sanctipauli, a sibling species of the Simulium damnosum complex as reported by Garms & Vajime, 1975. (Photograph by Dr. Eddie W. Cupp.)



Fig. 19. Black fly site #9: Yaa Creek near Zogowe (Nimba Co.), south of the Nimba mountain range; see Map 4. Drs. Cupp & Schiller visited this site on 11 December 1978. The Yaa Creek is narrow and heavily shaded--characteristic of breeding sites of Simulium yahense, another sibling species of the Simulium damnosum complex that was named for this creek, as reported by Garms & Vajime, 1975. (Photograph by Dr. Eddie W. Cupp.)



Fig. 204. Black fly site #10: Upper St. Johns River near the bridge from Bluff Co. to Red Co., near Bulla; see Map 4. The Cache. Team visited this site on 11 December 1978. This is a large river in a forested zone--characteristic of breeding sites of Simulium damnosum (s.s.), another sibling species of the Simulium damnosum complex, as reported by Garns & Voshell, 1975. (Photograph by Dr. Eddie W. Cupp.)