4. Review Articles Related to the Cooperation Project (Republications)

4) Preliminary Report of Japan-Guatemala Onchocerciasis Control Pilot Project*

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In 1915 Dr. R. Robles became the first to record American onchocerciasis from Guatemala, where it is accordingly called "Robles' Disease". He assumed that the vectors would prove to be blackflies and recommended that nodulectomy would be the effective treatment. Since his discovery, both original research and experimental trials concerning treatment and control measures have been carried out in this country. Indeed, Guatemala was the first country from which results of the practical use of DDT, as a larvicide against a blackfly vector of onchocerciasis, were published [1, 2]. Denodulization has continued to be practised there as a control measure for six and a half decades since this was first urged by Robles. The difficulty of vector control under local conditions was a contributory reason for this. Meanwhile, after detailed and careful preparation, OCP was launched in West Africa, late in 1974, by the Executing Agency, WHO. According to progress reports issued by WHO, this programme continues to show real promise [3].

Against this background, the government of Guatemala requested that of Japan to furnish technical cooperation with respect to onchocerciasis control. In March 1975 Japan sent a mission to Guatemala to study the feasibility of such cooperation. Its aims were to investigate the epidemiology of onchocerciasis, and existing disease control measures; and to recommend how best to organize the proposed venture. Accepting the report, Japan dispatched a second mission in June 1975 to negotiate protocol for a collaborative project. The activities discussed in this chapter, duly commenced in May 1976. By then, Japanese experts were on the spot and the necessary supplies and equipment had been received.

Entomological aspects of the project and progress over the first two years are outlined below. Much of the data so far obtained remaining unpublished, credit for this work should be assigned to the entomologists concerned with the project.

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Measures for the reduction of onchocerciasis include vector control, nodulectomy and chemotherapy. In the last-mentioned connection, diethylcarbamazine and suramin both have a role. However, because of the possibility of massive side effects, the greatest care is needed for the administration of these drugs. While they may be applicable to the treatment of individual cases, we do not yet have a basis for mass treatment, as ORSTOM and WHO experience in West Africa has shown.

While nodulectomy has been found beneficial in achieving some decrease in actual eye damage due to Onchocerca volvulus, it seems only of supportive (largely cosmetic) value, in a major control effort. It is submitted that the only really effective approach is the actual interruption of onchocerciasis transmission through vector control. Historically, the most conspicuous success in the latter connection was achieved again Simulium neavey in Kenya, a quarter of a century ago [4]. Currently, WHO’s OCP, commenced in the Volta River basin in late 1974, is achieving very promising results in suppressing the adult density of Simulium damnosum s.l. by the aerial spraying of Abate® formulations [3].

In Guatemala, large-scale vector control trials took place in the early 1950s [5, 6]. Approximately 1,500 streams, in an area of 205 km², were then treated with DDT without achieving more than a slight decrease in the adult blackfly population density.

In 1971 WHO sent Dr. J. P. McMahon to Guatemala, to investigate the feasibility of controlling onchocerciasis vectors [7]. He recommended larviciding, by ground or aerial application, emphasizing, however, the difficulty of implementation. He also outlined an appropriate research and training plan. In Mexico, the small-scale control of onchocerciasis vectors was initiated at the national level in 1930. After 1965, though, organizational changes reduced effectiveness [8]. When the present project commenced, no
organized onchocerciasis control activities existed in Latin America.

The aim of this venture is to determine the feasibility of blackfly control in Guatemala. A pilot project area has been established in the endemic zone, and intensive entomological, parasitological and epidemiological investigations have been initiated. This, though, is purely the preparatory phase for a control programme directed towards interrupting onchocerciasis transmission, by larviciding operations against *Simulium ochraceum*. From the results of this pilot project, it is anticipated that a control programme suited to the special difficulties faced in Guatemala will be developed. At the same time, local personnel will gain experience enabling them to staff a future, national-level campaign.

**ONCHOCERCIASIS IN GUATEMALA**

The Central American Republic of Guatemala has an area of 108,780 km² and a population of 6,500,000. Of the 22 Departments, under which the country is administered, at least seven are subject to onchocerciasis. There are four foci of the disease. Zones I and II are small, and located in Huehuetenango (northwest Guatemala, adjacent to Mexico). Zone III is an area of high endemicity, where workers on some coffee plantations have an infection rate of almost 100%, with >10% ocular and skin lesions and 1% blindness [9]. Zone IV is subdivided in to Zone IV-1 and IV-2. It is somewhat isolated, being located at the boundary of the Departments of Escuintla and Santa Rosa. In Zone IV, endemicity is low and ocular lesions and blindness are seldom seen. Zones III and IV total approximately

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*1978 estimate from Background Notes, US Department of State Publications, Office of Media Services, Bureau of Public Affairs, Washington DC, USA.*
125 × 35 km, with an area of between 4,000 and 5,000 km². They extend from 600–1,500 m above sea level on the Pacific slopes of the volcanic region. Scattered through them, are numerous coffee plantations.

According to the 1970 report of the Section of Onchocerciasis, Ministry of Public Health and Social Assistance, 56,820 inhabitants in the endemic area of 5,232 km² (total population: 385,000) were examined by the nodulectomy teams. Altogether, 5,189 were found to exhibit nodules. On this basis, it was estimated that there might well be approximately 31,145 such cases throughout the country. However, the actual number is now assumed to be several times that - obviously, this must be a multiple of the figure, for those showing nodules. Before 1976, there had not been any comprehensive surveys for endemcity (based upon microfilaria rate, as revealed by skin snips). According to data obtained during the period from 1946 to 1964 [10]. Acatenango has the highest nodule rate (32.7%). Cuiő, Yepocapa, San Lucas Tolimán and Santiago Atitlán show 30.7, 22.2, 21.5 and 21.6% respectively. At Recreo and Panajabal (in Yepocapa), microfilarial rates of 97% and 96%, respectively, were obtained.

The chief manifestations of American-type onchocerciasis are: onchodermata, nodules, erosion and blindness. The most severe symptoms relate to eye damage. Of 663 onchocerciasis cases examined [11] on seven plantations, keratitis, iritis and blindness were present in 50, 10 and 2.1%, respectively.

Until 1976 the Onchocerciasis Section of the Health Service Bureau, Ministry of Public Health and Social Assistance, was administratively responsible for measures against this disease. For more than 40 years, the only such measure had been nodulectomy. This work had been performed by brigades, each including six teams, consisting of one operator and one assistant. These brigades travelled through the endemic area twice or three times annually. Although some authorities considered that their efforts reduced blindness to some extent, there was no observable alteration in the annual incidence of nodules. One interesting finding, however, was that onchocerciasis endemcity is closely related to the distribution of coffee plantations. A distinct socio-economic factor must therefore be recognized as regards the onchocerciasis problem in Guatemala.

**DESCRIPTION OF THE PILOT-PROJECT AREA**

In selecting this area, the following criteria were given special weight. The area must: be representative of the endemic zones of Guatemala; be isolated, to avoid vector infiltration from surrounding localities not under blackfly control; have topographic barriers, whether mountains, valleys, lakes, etc.; be at least 50–100 km²; exhibit moderate onchocerciasis endemcity; include several coffee plantations; have permanent inhabitants; be easily accessible; and be as free as possible from flood hazards, etc.

Zone IV-1, located in San Vincente Pacaya, Department of Escuintla, proved to satisfy most of these relevant criteria, and it was decided to establish the pilot project there.

San Vincente Pacaya lies approximately 30 km south of Guatemala City. Volcan de Pacaya (2,500 m) is north-east of the project area, which extends to the southern Pacific slopes at 500–1,500 m. Municipio San Vincente Pacaya covers 236 km², and has approximately 6,300 inhabitants. The selected area comprises some 168 km² of the Municipio, measuring about 12 km from west to east and 14 km from north to south. It is on a slope in which some 1,000 m of altitude are lost in only 10 km. The equivalent of a natural barrier on the western border of the area is a highway, running through the valley from Guatemala City to Puerto San José. The other borders are with non-endemic areas to the north, east and south. The chief village of the project area is San Vincente Pacaya, near the northern border. A number of coffee plantations are scattered through the southern localities, their population being rather stable. Northward there are few permanent settlers, but some workers are employed outside the pilot area, in Palin, to and from which they travel daily.

**ENDEMICITY OF ONCHOCERCIASIS IN THE PILOT-PROJECT AREA**

The initial microfilarial survey in this area, revealed positive skin snips for 513 (33.2%) of the 1,540 inhabitants examined [12], with higher rates from villages at 700–1,200 m, than in those still higher (on the plateau above 1,700 m) or in the lowlands below 500 m. Of 1,318 people locally examined, a few years earlier [13], 127 (9.6%) exhibited nodules. In the present survey, which concerned 13 villages, the ratio of the microfilarial rate (based on a single skin snip) to the nodule rate (by palpation) showed close correlation. In males, the microfilarial rate rose with age (highest value, 75% in the 10–49 year age group). In females, though, it was about half that for males in each of the age group. It was thus suggested that the heavier parasitaemias of males may result from their being more frequently exposed than females to infective bites, for occupational reasons; as is well-known from other filariasis.

Among 500 persons found to have nodules, 56.5% exhibited these on the head (25.2% from occipital and 22.1% from parietal regions). The remaining 43.5% were
on the trunk (16.4% from the iliac regions and 6.2% from the scapular ones). A slit lamp was used to examine the eyes of 1,037 subjects, of whom 988 were also examined by skin snip. Sixty-one (6.2%) of these people had microfilariae in the anterior chamber, the incidence being 8.7% in males, and 2.5% in females. There was clear correlation between the anterior chamber positive rate and microfilarial density rate in the skin. As already mentioned, the only earlier onchocerciasis control measure practiced in Guatemala was nodulectomy. It is thus interesting to report that of 1,513 inhabitants examined, from San Vincete Pacaya, 540 (35.7%) had formerly experienced this operation.

**TIME SCALE FOR ENTOMOLOGICAL ASPECTS OF THE PILOT PROJECT**

The onchocerciasis control pilot project in San Vincete Pacaya was scheduled as a five-year plan; with preparatory, attack and evaluation phase (Table 1). The entomological activities in each phase were foreseen as set out below.

**Preparatory Phase**

**First Year (1976)**

The first priority was to determine the vector. Several anthropophilic blackfly species had already been recorded from the project area. It was thus crucial to success, to ascertain which of these was responsible for onchocerciasis transmission, so that future control could be focused accordingly. Towards this end, and in the interests of gathering adequate data on local Simuliidae and developing necessary methods for control evaluation, investigations were programmed as follows in the pilot area: survey of the blackfly fauna; investigations of the Simuliidae found to be anthropophilic; studies of the natural incidence of *Onchocerca volvulus* in adult blackflies; establishment of suitable methods for laboratory rearing of adult blackflies; observation of the development of *O. volvulus* in adult blackflies, under laboratory conditions; mapping of blackfly-breeding watercourses; investigation of larval habitats of the presumed chief vector, *Simulium ochraceum*; investigation of the biting behaviour of Simuliiidae; seasonal prevalence of blackflies; and studies of methods for evaluating vector control.

**Second Year (1977)**

Biological studies of the chief vector (probably *S. ochraceum*) continued, with particular respect to aspects relevant to control decisions, and particularly towards elucidation of the vector, with the mapping of the streams utilized as its larval habitats.

1. Vector elucidation: further studies of the natural incidence of *O. volvulus* in adult blackflies; and investigations of experimental infections with *O. volvulus* in Simuliiidae in the laboratory, with further studies of parasite development.

2. Vector biology: mapping of larval habitats of *S. ochraceum*; studies of the streams utilized by *S. ochraceum*; observation of the seasonal prevalence of adults and early stages of *S. ochraceum*; determination of the larval development period of *S. ochraceum*; investigation of the gonotrophic cycle of *S. ochraceum*; flight-range survey of adult *S. ochraceum*; and studies of methods for evaluating vector control.

**Third Year (1978)**

Decisions on control measures to be made in preparation for the Attack Phase in the following year, with particular attention to:

1. Larviciding procedures: selection and formulation of insecticide; determination of dosage; decisions on the frequency of larvicide applications; determination of the optimum season for larviciding; and selection of treatment points.

2. Operational planning: organization; and training of personnel and obtaining of supplies and equipment.

3. *O. volvulus* transmission analysis: determination of the vector density level, at and below which transmission is interrupted; and designing of a transmission model.

4. Pretreatment evaluation: studies of adult blackfly density; investigation of larval blackfly density; and estimation of annual transmission potential.

5. Investigation of the environmental impact of insecticiding.

6. Survey of predators, parasites and pathogens of blackflies.

**Attack Phase (1979)**

This phase of the five-year plan envisaged intensive larviciding against the vector throughout the pilot area. It was anticipated that ground parties would apply larvicides
to the head waters of streams on a weekly or fortnightly basis, for three months.

**Evaluation Phase (1980)**

After the first four years, there would be a comprehensive evaluation of procedures used and results achieved. Changes in vector density and the Annual Transmission Potential in the project area would be analyzed from entomological data collected before and after treatment. Any alterations in actual disease incidence would be determined by parallel epidemiological evaluation. The objectives of the pilot project would, hopefully, be attained by the end of this fifth year. Thereafter, the resultant standard vector control methodology would be available for country-wide implementation.

**Structure and Management of the Pilot Project**

The enterprise is conducted by the Guatemalan government, with the technical and financial cooperation of the Japan International Cooperation Agency (JICA). The project team operates within the Servicio Nacional de Erradicación de Malaria (SNEM), Dirección General de Servicio de Salud, Ministerio de Salud Pública y Asistencia Social. SNEM comprises five departments. One of these, Departamento de Programas Adscrito, is responsible for vector-borne diseases other than malaria, such as onchocerciasis, yellow fever and Chagas diseases. The onchocerciasis control project team is composed of four groups—epidemiological, parasitological, entomological and administrative. Japanese and Guatemalan scientists, technicians and administrators are assigned to these. Operational tasks, such as mapping and insecticide application are assisted and reinforced by the Departamento de Operaciones del Campo.

Some 10 Japanese specialists have long-term assignments to the team at all times. They include five entomologists, two parasitologists, two epidemiologists and a coordinator. In addition, at least six other experts are sent annually, for short-term involvement as occasion demands. The attack phase involved the temporary allocation, to the team, of from 10 to 20 field personnel from the Departamento de Operaciones del Campo, for actual control operations.

**The Vector**

As indicated, Robles [14] suggested that blackflies might be responsible for the transmission of onchocerciasis in Guatemala. Subsequently, experiments in Mexico [15, 16] demonstrated that *O. volvulus* will develop in *S. callidum* and *S. metallicum*. Strong [17] and Strong et al. [18] narrowed the choice of possible Guatemalan vectors to *S. ochraceum*, *S. callidum* and *S. metallicum*. De León [19] and Gibson [20], after natural infection surveys, reported the levels of *O. volvulus* in *S. ochraceum*, *S. callidum* and *S. metallicum*. On the other hand, Gibson and Dalmat [21], on the basis of their successful laboratory experiments, made the further suggestion that *S. exiguum*, *S. haematopotum* and *S. veracruzanum* might be potential vectors too. Dalmat [22] claimed that *S. ochraceum* might well prove to be the chief vector in Guatemala, for the following reasons: its distribution coincides closely with the area where onchocerciasis is endemic; although the distribution of *S. ochraceum* does not always exactly coincide with that of the Guatemalan onchocerciasis, its population density is substantially higher in the endemic zone than in unaffected areas; while *S. ochraceum* is an anthropophilic, the other blackfly species present are strongly zoophilic; and *S. ochraceum* feeds longer from humans than do the other species, and its behavior is sluggish afterwards.

Hamon [23] have lately pointed out, in a PAHO review document, that of three possible vectors in the Western Hemisphere, *S. ochraceum* might be the most important.

From the start, the project team accorded top research priority to pinpointing the chief vector. This was to avoid an otherwise unselective control campaign, costing greatly more than an operation aimed at a single target species. The conclusion was duly reached that the control campaign should be conducted against *S. ochraceum*, for the following reasons:

1. No adults of any other blackfly species were every found with infective larvae of *O. volvulus* in the head, during the team’s natural infection survey. The parous rate, and *O. volvulus* infection level of blackflies from human bait, were recorded for a full year (1977–1978) in the pilot area (Ochoa, personal communication). Of the approximately 7,300 adult simulids collected, 60.7% were *S. ochraceum*, 33.8%, *S. metallicum*, and 5.5%, *S. callidum*. Only 0.2% of the *S. ochraceum* proved to harbor infective larvae of *O. volvulus*. Considering the adults of all three species, some 1.6% exhibited larvae of this worm in the thorax and abdomen. Notably, although *S. metallicum* (thought to have been a possible secondary vector) never had *O. volvulus* in the head, 1.0% of the adults of this species dissected, had worms in other parts of the body. With respect to the third suspected vector, only one adult of *S. callidum* (out of approximately 400 examined) contained *O. volvulus* larvae; and this involved the abdo-
men. These data indicate the likelihood that only *S. ochraceum* is of importance to onchocerciasis in the pilot area.

(2) As mentioned earlier, there is good agreement between the range of *S. ochraceum* and the endemicity of onchocerciasis in the pilot area. Laval blackfly surveys revealed that the Chilar range (northeastern part of the pilot area) includes the main breeding sites of *S. ochraceum*. Although the rugged Chilar area (altitude 700–1,300 m) has few inhabitants, people from near villages maintain cultivations there. This region includes the headwaters of three significant streams, flowing southward through the pilot area. The distribution of human-biting *S. ochraceum* adults coincides with that of the larvae, such attacks being registered at altitudes of from 900–1,300 m above sea level. According to Tanaka et al. (personal communication), the relationship between biting adult density and altitude is self-evident (Table 2).

The parasite index of the human population in the Chilar region is significantly high, too. Tada [24, 25], using the skin snip method, obtained positive microfilarial rates of 7.7% in El Camarón, and 16% in Los Chaguítes, at an altitude of about 500 m. Higher such rates were recorded from El Patrocinio (38.4%, 1,600 m), Los Rios (49.5%, 1,500 m), Caña Vieja (62.3%, 700 m) and Berlin (77.3%, 600 m). Sato [26] demonstrated the applicability of antigen, prepared from adults of the dog heartworm, *Dirofilaria immitis*, to onchocerciasis diagnosis via skin tests. He applied the technique to determining the distribution of the disease in the pilot area. Table 3 shows the relationship of altitude to onchocerciasis rates, as estimated antigenically and by skin snip. Clearly, the highlands (600–1,300 m), where *S. ochraceum* attacks humans most vigorously, are the regions of highest endemicity.

(3) To explore the feasibility of altogether dismissing *S. metallicum* as an object of control, Matsuo [27] investigated anthropophilism in the pilot area. Adults collected at Guachipilin proved to comprise: *S. metallicum* (57.8%), *S. ochraceum* (21.9%), *S. callidum* (20.0%), and *S. downsi* and other infrequently encountered species (totalling 0.2%). Because *S. metallicum* is held to be the onchocerciasis vector in Venezuela [28], it obviously merited searching investigation in the pilot area. Ito and collaborators (personal communication) investigated the potential of *S. metallicum* as a vector, through experimental infection in the laboratory. They concluded that *O. volvulus* microfilariae were indeed able to develop to the infective larval stage, and to reach the head of this blackfly. It may therefore be asked why infective larvae have not yet been found in the head of *S. metallicum* in nature? Possible reasons are that this blackfly is so strongly zoophilic that an individual is unlikely to bite man more than two or three times in its entire life; and that it is physically damaged when (through too many microfilariae being ingested) the worms invade its various organs [29]. Ito (personal communication) discovered that most *S. metallicum* females die within a day of feeding from experimental subjects with high microfilarial density in the skin, because of such physical damage. Few *S. ochraceum* were found to die even after ingesting large numbers of microfilariae, because many of the latter were cut through or otherwise injured by the buccopharyngeal armature. Thirdly, *S. metallicum* shows a strong preference for biting the lower part of the body, where microfilarial density is lower than in the upper parts. Under natural conditions, their chances of actually ingesting microfilariae is thus reduced accordingly. For the three reasons suggested, it is considered that *S. metallicum* is unlikely to be of practical significance as a vector.

Therefore, while recognizing that *S. metallicum* could

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**Table 2.** The relation between the adult density of *S. ochraceum* attacking human bait and the altitude of the project area.

| Locality            | Altitude (m) | No. flies collected |
|---------------------|--------------|---------------------|
| Los Jazmines        | 1300         | 284                 |
| Los Lavaderos       | 1300         | 357                 |
| Rio Guachipilin     | 1200         | 136                 |
| El Rodeo (Palin)    | 1200         | 65                  |
| Finca Las Chilcas   | 900          | 30                  |
| Finca Las Esperanza | 600          | 3                   |
| Finca Berlín        | 600          | 6                   |
| Finca Peña Blanca   | 400          | 5                   |
| Finca Agua Blanca   | 300          | 0                   |

"Tanaka et al. (personal communication)."

**Table 3.** The relation between the skin test and skin-snip positive rates of onchocerciasis, and the altitude of the project area.

| Altitude (m) | No. tested | Positive rate % | Skin test | Skin test + skin-snip test |
|--------------|------------|-----------------|-----------|---------------------------|
| 1800–1700    | 126        | 23.1            | 24.0      |
| 1300–1200    | 114        | 42.1            | 48.0      |
| 1000–800     | 88         | 54.7            | 69.2      |
| 800–600      | 42         | 53.3            | 77.8      |
| 400          | 25         | 35.7            | 37.1      |

"Sato et al. (1978)."
certainly act as a major vector under circumstances where few animals exist as sources of blood-meals, or where human onchocerciasis is of low endemicity, it is concluded that the species can be safely ignored in the target area—at least during the earlier phase of the campaign. However, it is submitted that once onchocerciasis endemicity falls appreciably, following successful S. ochraceum control, S. metallicum might well become an alternative vector.

VECTOR BIOLOGY

Larval Habitats of S. ochraceum

Dalmat [22] proposed a classification for Guatemalan streams having blackfly breeding sites, on the basis of relative age. He graded them as “infant”, “young”, “adolescent”, “mature” and “old”, in accordance with their size, form, current-flow, substrate and vegetation. He further pointed out that the principal anthropophagic blackflies, then assumed to transmit onchocerciasis, prefer “infant” or “young” streams, or parts thereof. The preparatory phase of the pilot project confirmed that S. ochraceum principally used “infant” streams and only occasionally “young” ones.

The characteristics of S. ochraceum larval habitats are: convergence of several minute trickles from rocks; no definite bank trough; stream bed hardly distinguishable from the dry surroundings; tributaries of “young” or “adolescent” streams; and “miniature waterfalls”, perhaps no more than a moving film of water over rock.

Physical parameters for typical S. ochraceum larval habitats have been summarized by Tanaka et al. (personal communication). They range from 3–100 cm in width, 1–10 cm in depth, 10–500 m in length, 0.1–10.0 l/sec in volume, 15–50° incline, and have a water temperature of 18–22°C. In the pilot area, such habitats are typical of the rugged Chilar terrain (700–1,300 m above sea level), whence most of the rivers originate.

Seasonal Prevalence of S. ochraceum

In Yepocapa, larvae, pupae and adults of S. ochraceum may be found throughout the year, with adult population peaks in January and August [22]. This same authority stated that the ensuing larval population peak in April and October. However, not all these findings were confirmed by our preparatory phase data. While larvae, pupae and adults were indeed found throughout the year, there was only a single population peak for each life-history stage. The larval peak was especially noteworthy, being reached during the dry season, between October and April. During the rainy season, from May to October, the density of S. metallicum larvae remained rather low.

Adults failed to show so evident a population peak. Their numbers were lowest between July and November. From the control stand point, the best season for larviciding thus seemed to be during the dry months—from October onwards.

Feeding Behaviour of S. ochraceum

S. ochraceum is a day-biter, which has not been found to exhibit any noticeable diurnal rhythm. Its attack is usually confined to upper parts of the body. This behaviour is in sharp contrast to the other characteristic blackflies of the area (S. metallicum, S. callidum, S. gonzalezi and S. downsi)—these, as already mentioned prefer to bite lower down [22, 27]. It is submitted that these contrasting behaviour patterns are of great importance, epidemiologically; for as microfilarial density is highest in the skin, e.g. the face and trunk, it is much reduced in the lower extremities [30]. S. ochraceum clearly has better opportunities than the other species for feeding from parasitized humans.

Gonotrophic Cycle of S. ochraceum

Laboratory and field observations [31] suggest the following gonotrophic cycle for this species: females mate one day after emergence, taking a blood meal within a further day; maturity of their ovaries takes place about four days later; the period from one blood meal to the next is approximately five days at 22°C; and the extrinsic period for O. volvulus microfilariae to develop into infective larvae and reach the head of the vector is at least eight days at 25°C or four days at 30°C [32].

These data suggest that microfilariae ingested at the first feeding develop in to infective larvae at the time of the third or fourth blood-meal.

VECTOR CONTROL MEASURES

S. ochraceum has been found breeding in some 50 trickles and streams of four of the main rivers in the pilot area. This species is also suspected of utilizing several times more such larval habitats; from which, however, it has yet to be recorded.

The results of laboratory and field experiments in the preparatory phase (Tabaru and Shimada, personal communication), have shown that temephos 10% slow-release briquettes are appropriate to the project. Not only are they larvicidally effective, but they are convenient to use, and pose minimum adverse effects to NTOs.

Field experiments using these briquettes so that the dosage of temephos was 10 ppm/minute, led to the continuing absence of S. ochraceum larvae for two weeks following treatment. It was concluded that successive

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insecticide applications should probably be undertaken in just under this period, treatment of each stream or trickle taking place at only two sites.

On this basis, and assuming the need for 400 application sites (i.e. on 200 trickles or streams in the pilot area) a single spraying team, composed of two field operators, could treat eight sites daily. Further assuming bi-weekly intervals of application and a five-day working week, only 10–15 field operators, including the supervisor, would suffice for the entire operation.

POSTSCRIPT: In the Lavaderos River basin located in the northern part of the pilot area, the larviciding operation was launched in March 1979 applying 10% temephos briquettes of two-weekly intervals. Twenty-four tributaries having been mapped by then for the Lavaderos River, insecticide treatment were implemented at 47 sites of the watershed; by September 1979 coverage had increased to 88 sites. Two kinds of entomological evaluation were adopted. One involved the periodical estimation of adult blackfly density by means of collections from human bait; the other called for the periodical assessment of larval and pupal density, one such reading always being obtained nine days after each application. It proved that larval density decreased rapidly soon after each temephos application, subsequent searching revealing neither old larvae nor pupae in most tributaries. Collections from a bait-boy showed that the number of simuliiids attempting to bile at first fluc-
tuated between 26 and 524 during three-hour observation periods before pesticide treatments, but then decreased remarkably, so that from June to December, adult density remained between 0 and 21 (Nakamura, personal communication).

In the Barretal and Zapote River basin, adjacent to the Lavaderos River, two-weekly larviciding was commenced in June 1979 at 83 sites on 44 tributaries. Although it has been difficult to find larvae there, during the post-treatment assessments, adult blackfly population decreases have proved much less marked in the Barretal/Zapote zone than in the Lavaderos River basin. The reason for this is suspected to be invasion from the southern area not under blackfly control (Takahashi, personal communication).

The larviciding of the Guachipilin River basin will commence in March 1980. The mapping of this watershed has shown that there are approximately 140 tributaries, totalling some 33 km in length. This entire operation (Lavaderos, Barretal, Zapote and Guachipilin River basins) requires four application teams and one evaluation team, each composed of two or three field personnel (Takahashi, personal communication).

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REFERENCES

1. Fairchild GB, Barreda EA. DDT as a larvicide against Simulium. J Econ Ent 1945; 38: 694–699.
2. Jannback H. The origins of blackfly control programmes. Blackflies. The future for biological methods in integrated control. London: Academic Press; 1981. pp 71–73.
3. Walsh JF, Davies JB, Cliff B. World Health Organization Onchocerciasis Control Programme in the Volta River Basin. Blackflies. The future for biological methods in integrated Control. London: Academic Press; 1981. pp 85–103.
4. McMahon J, Highton RB, Goiny H. The eradication of Simulium neavei from Kenya. Bull Wild Hlth Org 1958; 19: 75–107.
5. Lea AO, Dalmat HT. Field studies on larval control of black flies in Guatemala. J Econ Ent 1955; 48: 274–278.
6. Lea AO, Dalmat HT. A pilot study of area larval control of black flies in Guatemala. J Econ Ent 1955; 48: 378–383.
7. McMahon JP. Report on the visit to the endemic areas of Robles disease (Onchocerciasis) in Guatemala, 8–25 September 1971. PAHO. Mimeogr. Doc. 1971.
8. Mallén MS. Onchocerciasis in Mexico. Int. Symp. Research and Control of Onchocerciasis in the Western Hemisphere. PAHO Scient Publ 1974; 298: 112–115.
9. Figueroa Marroquin H. Robles’ disease (American onchocerciasis) in Guatemala. Int. Symp. Research and Control of Onchocerciasis in Western Hemisphere. PAHO Scient Publ 1974; 298: 100–104.
10. Garcia Manzo GA. Enfermedad de Robles, su morbilidad y proyecciones socioeconomicas. Boletin Sanitario 1965; 61: 121–130.
11. Estrada SC, Bernhard JA, Figueroa LN, et al. Epidemiologia, Enfemedad de Robles. Guatemala: Editorial Universitaria; 1963. pp 83–121.
12. Tada I, Aoki I, Rimola CE, et al. Onchocerciasis in San Vicente Pacaya, Guatemala. WHO/ONCHO/77.140. Mimeogr. Doc. 1977.
13. Garcia Manzo CA. La onchocercosis en Guatemala. Breve resumen preparado para información de los asistentes al congreso nacional de salud. Unpubl. Doc. 1971.
14. Robles R. Onchocercose humaine au Guatemala produisant la cécité et l’érysipéle du litoral. Bull Soc Path Exot 1919; 12: 442–460.
15. Hoffmann CC. Nuevas investigaciones acerca de la transmisión de la oncocercosis de Chiapas. Revta méx Biol 1930; 10: 131–140.
16. Hoffmann CC. Estudios entomologicos y parasitologicos acerca de la oncocercosis en Chiapas. Salubridad 1931; 3: 669–697.
17. Strong RP. Onchocerca investigations in Guatemala. Report of progress of the Harvard Expedition. New Engl J Med 1931; 204: 916–920.
18. Strong RP, Sandground JH, Bequaert JC, et al. Onchocerciasis with special reference to the Central American form of the disease. Contr Harv Inst Trop Biol Med 1934; 6: 1–234.
19. De León JR. Entomología de la Onchocercosis. In “Onchocercosis”. Guayaquil, Guatemala: Univ. San Carlos; 1947. pp 147–172.
20. Gibson CL. Parasitological studies on onchocerciasis in Guatemala. PhD thesis, Univ. of Michigan; 1951.
21. Gibson CL, Dalmat HT. Three new potential intermediate hosts of human onchocerciasis in Guatemala. Am J Trop Med Hyg 1952; 1: 848–851.
22. Dalmat HT. The black flies (Diptera: Simuliidae) of Guatemala and their role as vectors of onchocerciasis. Smithsonian Misc Collns 1955; 125: 1–425.
23. Hamon J. Onchocerciasis vectors in the Western Hemisphere. A. Vector biology and vector-parasite relationship. Int. Symp. Research and Control of Onchocerciasis in Western Hemisphere. PAHO Scient Publ 1974; 298: 58–68.
24. Tada I. Distribution of onchocerciasis cases in San Vicente Pacaya. Onchocerciasis control project in
25. Tada I. Studies on onchocerciasis in Ethiopia and Guatemala. Research in filariasis and shistosomiasis 1978; 3: 173–194.

26. Sato S. Immunological and parasitological investigation of onchocerciasis in Guatemala. Onchocerciasis control project in Guatemala, First report. Tokyo: JICA; 1978. pp 107–127.

27. Matsuo K. Taxonomic and ecological investigations of onchocerciasis vector in Guatemala. Onchocerciasis control project in Guatemala, First report. Tokyo: JICA; 1978. pp 13–54.

28. Convit J. Onchocerciasis in Venezuela. Int. Symp. Research and Control of Onchocerciasis in the Western Hemisphere. PAHO Scient Publ 1974; 398: 105–109.

29. Omar MS, Garms R. Lethal damage to Simulium metallicum following high intakes of Onchocerca volvulus microfilariae in Guatemala. Tropenmed Parasit 1977; 28: 109–119.

30. De León JR, Duke BOL. Experimental studies on the transmission of Guatemalan and West African strain of Onchocerca volvulus by Simulium ochraceum, S. metallicum and S. callidum. Trans R Soc Trop Med Hyg 1966; 60: 735–752.

31. Watanabe M. Observations on the gonotrophic cycle of Simulium ochraceum. Onchocerciasis control project in Guatemala, First report. Tokyo: JICA; 1978. pp 61–68.

32. Collins RC, Campbell CC, Wilton DP, et al. Quantitive aspects of the infection of Simulium ochraceum by Onchocerca volvulus. Tropenmed Parasit 1977; 28: 235–243.