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ONCHOCERCIASIS IN ECUADOR: THE SITUATION IN 1989

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Details are given of the prevalence rates of onchocerciasis from the most recent surveys (1989) conducted in northern Ecuador. The disease has intensified and dispersed considerably due to migration of infected individuals and the presence of a highly efficient vector. Comparison of these data with those from two previous surveys carried out in 1982/83 and 1986 and correlated with entomological findings highlight the danger of the formation of new foci of onchocerciasis in areas currently free of the disease. Recommendations are made for further entomological studies in areas either recently or likely to be affected by the disease where potential vectors are unknown or different to those registered in the Santiago focus. Ivermectin treatment with local vector control in specific areas is advocated to reduce the disease to a low level of public health importance.

Key words: onchocerciasis – prevalence – dispersal – control – Simuliidae

The first confirmed case of infection by *Onchocerca volvulus* in Ecuador was of a black male from the Rio Cayapas in the north west of Esmeraldas province in 1980 (Carvajal & Zerega, 1980). Subsequent epidemiological studies delineated the geographical limits of the disease, (Arzube, 1982; Guderian et al., 1982, 1983a) its prevalence and intensity of infection, (Guderian et al., 1983b) its clinical manifestations, (Guderian et al., 1984; Hay et al., 1989) the principal vectors implicated in its transmission (Shelley & Arzube, 1985; Takaoka et al., 1988) and possible measures for its control (Guderian et al., 1987a; Guderian, 1989; Shelley (1991).

Data collected in 1982-3 and 1986 indicate that the endemic foci of onchocerciasis in Ecuador are found only in the province of Esmeraldas (Guderian et al., 1989). The principal focus is located in the Santiago basin and involves the inhabitants (Chachi Indians & blacks) of villages on the rivers Cayapas, Onzoles and Santiago and their tributaries (Guderian et al., 1983a). Six satellite foci occur on the rivers Canandé, Cojimies, Sucio, Verde, Vilsa and Viche and have been formed by the migration of Indians from the main focus (Fig. 1) (Guderian, 1983a, 1987b). In 1982, 2251 people were infected with the disease (28.6% of 7868 examined), but by 1986 the number had increased to 4206 (39.5% of 10634 examined) (Guderian et al., 1988).

Onchocerca volvulus is transmitted by *Simulium exiguum s. l.* as a primary vector and *S. quadrivittatum* as a secondary vector in the Santiago focus (Shelley & Arzube, 1985; Takaoka et al., 1988; Arzube & Shelley, 1990). These two vectors also occur in the satellite focus at the Rio Canandé where the less common *S. incrustatum* (a secondary vector in the highland areas of the Amazônia focus of Brazil and Venezuela) bites man. The simuliid fauna of other satellite foci is not known. Recent taxonomic studies on the primary vector have shown *S. exiguum* to be a complex of three sibling species, the Cayapa, Aguarico, and Bucay cytospecies as well as the Quevedo form, which is closely related to the Bucay sibling (Procunier, 1989). The Cayapa cytospecies has been directly incriminated as a vector of *O. volvulus* (Shelley et al., 1986) and all three cytospecies and the Quevedo form have been shown experimentally to be good hosts to this filaria (Shelley et al., 1990a, b). *Simulium exiguum* has a wide distribution in Ecuador occurring at numerous localities be-

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tween 50-2000m above sea level on both the Amazon and Pacific sides of the Andes (Shelley et al., 1989).

The increasing public health importance of this disease through an increase in prevalence and intensity of infection over the past six years in the Santiago and Canandé foci has already been demonstrated (Guderian et al., 1988, 1990). That this is due to the efficiency of the primary vector *S. exiguum s. l.* can be clearly seen by correlating parasitological data (Guderian et al., 1987b, 1988) with independently collected entomological data for the village of Naranjal in the Canandé focus. Here, the increase in prevalence rates from 1980 to 1986 of 15.3% to 37.7% is explained by the high natural infectivity (1%) and daily man-biting rates (2000) of *S. exiguum* Cayapa cytospecies (Procunier et al., 1986; Shelley et al., 1986; Shelley, 1988).

The risk of onchocerciasis disseminating to other parts of Ecuador was considered high because of a combination of the nomadic nature of many of those infected with the disease, development of areas of Esmeraldas province involving a considerable interchange of people, and the almost universal presence of the primary vector in Ecuador allowing the formation of new foci if the parasite were introduced (Guderian et al., 1983a; Shelley, 1988). Several areas have experienced this population movement in recent years, in particular to the north of the Rio Santiago, to the east of the Andes associated with the oil fields at Lago Agrio, and in the oil palm plantations between the Canandé focus and Santo Domingo de Los Colorados to the south of the main focus.

The objectives of this paper are to report the current status of onchocerciasis in Ecuador based on new parasitological data from previously infected sites and from areas recently colonised, highlight its current active dispersal, and to present suggestions on the control of the disease.

MATERIALS AND METHODS

The presence of onchocerciasis was detected by skin biopsies using the methodology of previous surveys (Guderian et al., 1983b), the clinical condition of patients was noted and a census of local inhabitants made. Occasional collections of simuliids were made wherever possible. The present paper is only concerned with parasite prevalence rates from these surveys, a full epidemiological analysis being given elsewhere (Guderian et al., in press). Four areas were investigated in this work:

Santiago focus and Rio Mataje – A systematic epidemiological study was carried out during the rainy seasons between January to July of 1989 at localities previously sampled in the Santiago basin and in the area to the north of the main Santiago focus adjacent to the Rio Mataje. Since 1986 there has been a great influx of people to this area, especially of Awa indians from Colombia. Localities along the railroad linking San Lorenzo to Lita were also sampled because this is the main means of transportation from the fertile regions between the coast (San Lorenzo) and the Andes. The accompanying road presently under construction will further assist population movements (Fig. 1).

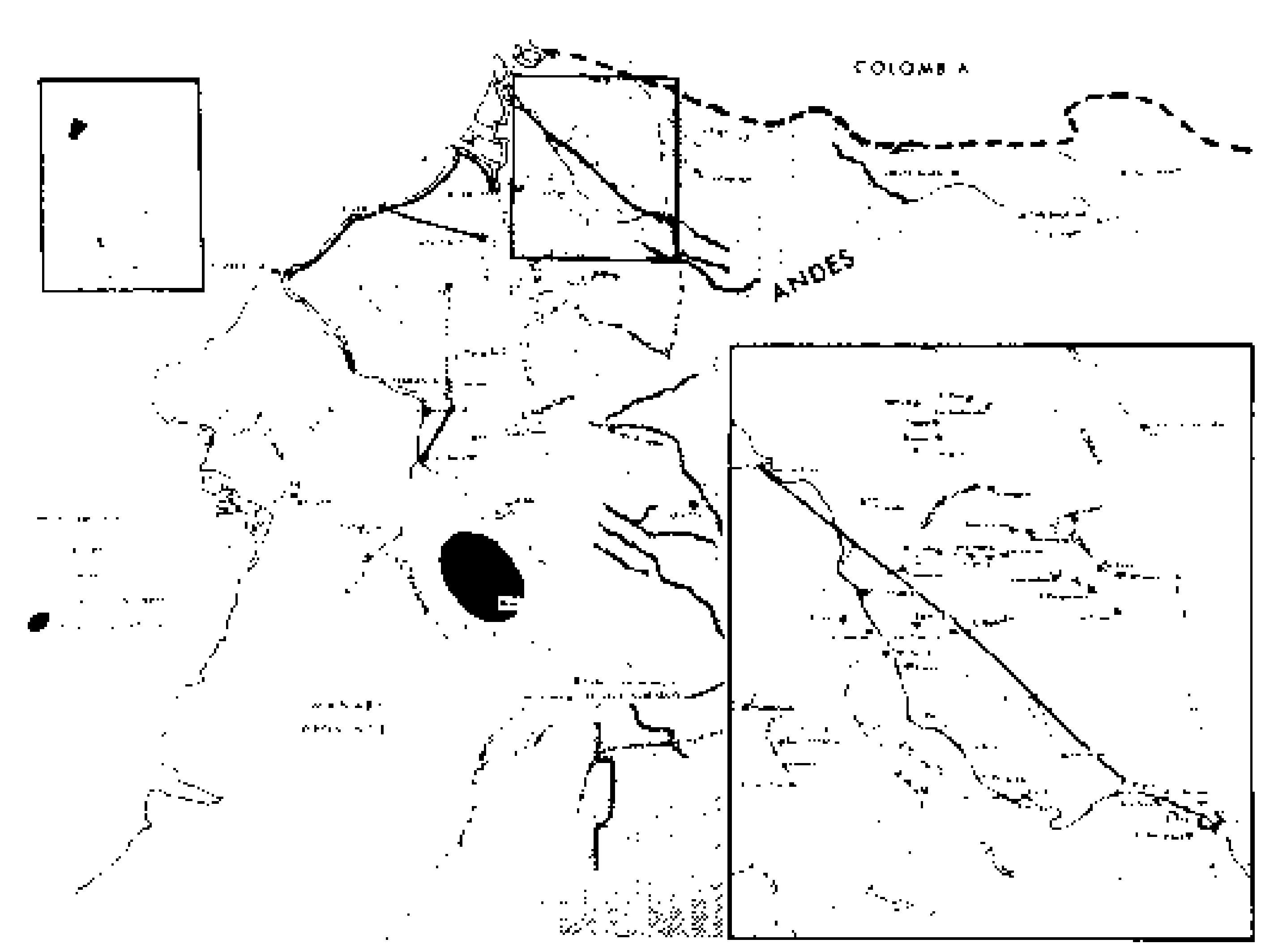

Fig. 1: localities surveyed for onchocerciasis.

Satellite foci – The construction in 1984 of a dirt road linking Colon (near Quinindé) at the mouth of the river Canandé to Cote in the upper reaches of the river has assisted development of this area by agricultural workers from the Province of Manabi. The extension of this road from Cote to San Lorenzo (Fig. 1) will further facilitate access to the main focus and the Canandé peripheral focus. Access to the other satellite foci remains difficult. To determine the expansion of the disease in the satellite foci surveys of new colonists as well as individuals not previously tested from infected areas were made in communities on the rivers Canandé, Sucio, Verde, Vilsa and Viche. The community on the R. Cojimies was not included because no new colonists have reached this locality.

South of the Santiago focus – This was selected because of the migration, in the last two years, of a group of 142 Chachis from the Rio Cayapas to Congoma and Bua in the Santo Domingo de los Colorados area, province of Pichincha, in search of employment. Their work is primarily in agriculture working with local people in the African oil palm plantations (Fig. 1).

East of the Andes – Four communities were tested in 1987 in the area of the Lago Agrio oilfield because some of the workforce originating from the Santiago basin remained in the area after construction of the oil pipeline to Esmeraldas.

RESULTS

The total population in the main Santiago focus (including the ferrocarril and Rio Mataje) and the satellite foci was estimated at 17,167 in 1989. Of these 15,833 individuals were sampled in all onchocerciasis foci except the Rio Cojimies and 36.6% (5788) were positive for the disease. Prevalence rates for the two previous surveys made were: 28.6% (2251) positive in 7,868 sampled in 1982/83 and 43% (4202) positive in 9,773 sampled in 1986. The following analysis of the data for 1989 shows that prevalence rates and microfilarial skin densities had increased at many localities and that the lower overall prevalence rate in this survey was caused by the inclusion of data from previously uninfected areas to investigate the dispersal of the disease.

Santiago focus and Rio Mataje – Data from newly infected areas within and adjacent to the main Santiago focus are detailed in Tables I-III, while skin microfilarial densities and prevalence rates for rivers where the disease was already established are given in Table IV and in the overall summary in Table VI.

Villages in the canton of San Lorenzo on the following northern tributaries of the river Santiago were first sampled (Fig. 1): Guimbi, Guimbicito, Estero Maria, Bogota, Cachavi, Tululvi, Palavi, and Quebrada Grande. The same area was tested in 1982-3 and 1986 but onchocerciasis was only present in some individuals at localities on the rivers Bogota and Tululvi (Guderian et al., 1983a). Communities between Quebrada Grande and the Rio Mataje (La Florida, La Chiquito, Biquari, Pigare, Chanual) and on the Rio Mataje (El Pan, La Redonda and Casa Comunal de Awas) were then investigated followed by all communities located on the railroad line (ferrocarril) from San Lorenzo to Lita. None of the communities in the two latter areas had been previously sampled. A total of 4,244 individuals were examined in the 53 communities of this area (Tables I, II, III; Fig. 1). Of these 8.6% (365) were positive for onchocerciasis and the disease occurred in nearly all localities sampled.

Prevalence rates and skin microfilarial densities were highly variable at localities on the northern tributaries of the Santiago river. Prevalence rates were low at localities on the Estero Maria, Rio Guimbicito, Rio Cachavi and Rio Bogota (Table I). There had been no change in prevalence rates on the previously sampled Rio Bogota but all other localities showed newly recorded infections. Skin microfilarial densities were low in all cases varying between 4.2-12.1 mff/mg. No nodules, ocular or skin lesions were seen.

Prevalence rates were higher on the Rio Guimbi (14.6%) and Quebrada Grande (17.1%) but skin microfilarial densities were low and no nodules, eye or skin disease were noted. The community Guadualito on the Quebrada Grande is populated by Awa indians, who may have arrived infected from Colombia or acquired the infection through their constant contact with the community Dos Juntos on the Rio Palavi.

The highest prevalence for onchocerciasis on all rivers examined was found at the Rio Tululvi (53.1%). The two communities with the highest prevalence rates and skin densities there, La Cieva (75.8%) and La Respalosa (77.7%), are populated by the Chachi race. Several years ago the disease was introduced into this area by migration of Chachi families from the Rio Cayapas and the disease has now worsened in this ethnic group. In the last six years the disease has extended down river from the Chachi to the black communities at La Loma, Cordova and Calle Mansa where lower prevalence rates and skin densities were found. Ocular and skin pathology due to onchocerciasis were only seen in the Chachi. No palpable

TABLE I

Prevalence rates of onchocerciasis in communities on northern tributaries of the Rio Santiago focus (1989 survey)

Geographical Area	No. examined	No. +	(%)	Mff skin density ± S.D.
Estero Maria				
Colon Eloy	412	13	(3.2)	
Valdez	271	11	(4.1)	7.3 ± 1.5
San Antonio	103	4	(3.9)	
Rio Guimbi	213	31	(14.6)	6.2 ± 1.1
Rio Guimbicito	98	5	(5.1)	8.1 ± 0.9
Rio Cachavi				
San Jose	193	7	(3.6)	11.2 ± 1.4
Rio Bogota				
San Francisco	281	2	(0.7)	11.1 ± 1.8
Santa Rita	123	3	(2.4)	4.2 ± 0.7
Carondelet	361	6	(1.7)	12.1 ± 1.4
Chillavi	95	3	(3.2)	8.9 ± 0.9
Rio Tululvi				
La Cieva	58	44	(75.8)	28.2 ± 3.6
La Respalosa	9	7	(77.7)	24.6 ± 2.7
La Loma/Guayabal	13	3	(23.1)	12.1 ± 1.4
Cordova	21	5	(23.8)	9.6 ± 0.5
Calle Mansa	12	1	(8.3)	–
Rio Palavi				
Campana	30	7	(23.3)	8.7 ± 0.8
Panbilar/Est. Natividad	43	5	(11.6)	10.1 ± 1.1
Balsareno	12	6	(50.0)	6.5 ± 0.7
Dos Juntos	46	23	(50.0)	9.1 ± 1.2
Quebrada Grande				
Guadualito	41	7	(17.1)	7.4 ± 1.2
Total	2,435	193	(7.9)	

TABLE II

Prevalence rates of onchocerciasis in the areas adjacent to the R. Mataje on the Ecuador-Colombia border (1989 survey)

Geographical Area	No. examined	No. +	(%)	Mff skin density ± S.D.
La Florida	38	0	(0)	–
La Chiquito/Pigare	42	10	(23.8)	15.3 ± 2.1
Chanual/Biquari	75	8	(10.6)	9.1 ± 1.7
Rio Mataje				
El Pan	41	19	(46.9)	7.6 ± 1.2
La Redonda	21	12	(57.1)	13.1 ± 1.9
Casa Comunal Awa	26	9	(34.6)	11.3 ± 2.3
Total	243	58	(23.9)	

TABLE III

Prevalence rates of onchocerciasis along the railroad line (ferrocarril) and surrounding areas from San Lorenzo to Lita (1989 survey)

Geographical Area	No. examined	No. +	(%)	Mff skin density ± S.D.
Ricaute	326	65	(19.9)	5.3 ± 1.1
Calderon	107	4	(3.7)	9.4 ± 0.9
San Javier	127	4	(3.1)	8.3 ± 1.5
Urbina	114	2	(1.8)	6.2 ± 1.1
La Pena/Playon	41	0	(0)	–
Guabina	23	4	(17.4)	7.4 ± 0.8
Los Ajos	18	3	(16.7)	8.1 ± 0.9
El Progresso	66	3	(4.5)	10.1 ± 1.7
San Jose	21	1	(4.8)	14.0 ± 0.0
Km 322/Km 310	148	2	(1.4)	9.2 ± 2.1
El Placer/Carchi	56	2	(3.6)	5.3 ± 1.1
Alto Tambo/Dos Arajes	66	5	(7.6)	6.9 ± 2.0
Anchayacu/Guadual	62	2	(3.2)	13.2 ± 1.3
Buffalito/La Bocana	31	3	(9.7)	9.7 ± 1.4
El Barreque	20	0	(0)	–
Lita	294	11	(3.7)	8.8 ± 0.6
Lita (Compania)	46	3	(6.5)	9.5 ± 1.5
Total	1,566	114	(7.3)	

nodules were found. (For further details on these communities see Guderian et al., in press).

The second highest prevalence of onchocerciasis was seen on the Rio Palavi (31.3%), which was negative in the 1982-83 survey. Awa Indians from Colombia are predominant in the area. In the communities with the highest prevalence, Dos Juntos and Balsareno (50.0%) it is not clear whether the disease was introduced by Chachi men from the Rio Cayapas or by their Awa wives previously infected in Colombia. Those Awa living in Campana, Panbilar, Estero Natividad, are in constant contact with the village Dos Juntos, where the school and Casa Comunal are located. No modules or ocular pathology due to onchocerciasis were found, though skin pathology was prominent despite the presence of low densities of microfilariae in the skin.

Prevalence rates were variable, ranging from 0-57.1% at localities near the Rio Mataje (Table II, Fig. 1). The area is populated by the Awa race except for a small black community found at El Pan on the Rio Mataje. In this community, on the border between Colombia and Ecuador, the blacks as well as the Awas were positive for the disease. In the communities La Redonda and Casa Comunal, areas populated only by the Awa race, a relatively high prevalence of 57.1% and 34.6% respectively was seen with 5 year old children positive for microfilariae. No nodules or eye disease due to onchocerciasis were found. Skin problems due to both fly bites and onchocercal microfilariae were present.

To evaluate the status of the disease of those living along and in surrounding areas of the railroad (ferrocarril) 1,566 people in 23 communities were examined (Table III). Prevalence rates and skin microfilarial densities were generally low in this area. The town of Ricaute was found to have the highest prevalence of disease (19.9%) with both skin and anterior and posterior segment eye onchocercal lesions being found. Two other communities showing similar prevalence rates were Guabina (17.4%) and Los Ajos (16.7%). The prevalence rates for all other communities varied from 0% to 9.7%. Those individuals positive for the disease had had no contact with any other onchocercal foci. Onchocerciasis was, therefore, probably introduced into the area by the arrival of infected people from Colombia. Large numbers of Colombians live in these localities and some recent arrivals were found to be already infected with onchocerciasis.

At localities along the remaining rivers of the Santiago focus shown to be positive for the disease in the 1982/83 and 1986 surveys prevalence rates had substantiatlly increased on all

TABLE IV

Skin microfilarial densities (mff/mg ± S.D.) at localities on six rivers of the Santiago basin

River	1982/3	1989
Hoja Blanca	15.2 ± 1.3	21.3 ± 2.3
Chimbagal	19.4 ± 1.9	28.9 ± 2.7
Grande	27.3 ± 2.4	51.8 ± 3.6
Cayapas	22.6 ± 1.6	41.3 ± 2.6
Onzoles	6.9 ± 0.8	6.2 ± 1.0
Santiago	20.1 ± 1.8	38.4 ± 2.9

TABLE V

Prevalence rates of onchocerciasis in new colonists in the satellite foci (1989 survey)

Geographical Area	No. examined	No. +	(%)
Rio Verde			
Merive	354	0	(0)
Estero Hondo	65	0	(0)
Rio Viche			
below Chorera Grande	105	0	(0)
Rio Sucio			
below San Salvador	265	0	(0)
Rio Vilsa			
below Sosa	79	0	(0)
Rio Canandé			
above Pava	286	32	(11.2)
Total	1154	32	(11.2)

rivers except the Onzoles and Santiago (Table VI). The survey on the R. Onzoles showed a reduction of prevalence rate in 1989 because few of the newly examined people were infected and a substantial number of infected young men had left the area to search for employment in Esmeraldas and Guayaquil. However, the overall prevalence rate remained static between the 1986 and 1989 surveys on the R. Santiago because the low prevalence rate in newly surveyed downriver localities balanced the increased rate in localities previously affected by the disease (Guderian et al, in press). A comparison of skin microfilarial densities sampled at localities on six of the rivers of the main focus of the Santiago basin shows a substantial increase in all except the R. Onzoles between 1982/3 and 1989 (Table IV).

Satellite foci – Results of surveys of recent colonists of the satellite foci are given in Table V. It is clear that in communities on the rivers Verde, Viche, Sucio and Vilsa the disease remains stable and has not dispersed to previously uninfected communities. However, on the river Canandé onchocerciasis has now affected the colonists from Manabi Province, 11.2% of whom were infected. No nodules, eye lesions or skin pathology were noted and skin microfilarial densities were low. Their settlements are more in the higher reaches of the river while those of the Chachi are towards the mouth of the river. The overall infection rates for the satellit foci, including new colonists and residents reexamined in 1989 are given in Table VI. Comparison of these data with results from the two previous surveys shows prevalence rates to have only increased at the R. Canandé. This again indicates that active transmission occurs only along this river.

Prospection for simuliids was carried out along various rivers in the satellite foci but no *S. exiguum s. l.* was recorded. No Simuliidae were found at the rivers Sucio or Vilsa, and only the largely zoophilic species (*S. lewisi, S. bipunctatum*) and small numbers of *S. escomeli*) at Balsar (Rio Cojimies). These three species, together with *S. mexicanum* were collected at the R. Viche. The only area where *S. exiguum s. l.* has so far been recorded is at the Canandé.

South of the Santiago focus – All 142 Chachis were positive for onchocerciasis with skin densities ranging from 28 to 56 (mean 36.7; S. D. ± 6.8) mff/mg. 124 Colorado Indians examined from the area were negative.

East of the Andres – Tests in 1987 on 861 negroes working in the Lago Agrio oilfields and living at four localities in its vicinity (Loreto, Campamiento de Shushufindi, Palmera de Ecuador and Palma Real) showed four to be infected with onchocerciasis.

Surveys for simuliids in the region of Lago Agrio showed the presence of *S. exiguum* Aguarico form in only the larger rivers San Miguel and Aguarico and in a small tributary of the latter, the R. Duvino (Procunier et al., 1986). The only species present in the smaller streams between Lago Agrio and Shushufindi were the zoophilic species *S. quadrifidum* and a species near *S. lewisi* (Shelley & Arzube, unpublished data).

DISCUSSION

New status of onchocerciasis in Ecuador – Parasitological surveys since 1986 have shown

TABLE VI

Summary of prevalence rates of onchocerciasis in Ecuador (1982/83, 1986 & 1989 surveys)

Geographical Area	Population	1982/83 +/ex.	(%)	1986 +/ex.	(%)	1989 +/ex.	(%)
Santiago basin							
R. Hualpi	26	11/13	(85)	17/18	(94)	24/24	(100)
R. Hoja Blanca	195	52/64	(82)	50/52	(96)	189/189	(100)
R. Chimbagal	359	155/194	(80)	294/308	(95)	340/340	(100)
R. Grande	440	270/376	(72)	459/470	(98)	428/431	(99)
R. San Miguel	465	234/412	(57)	416/421	(99)	450/452	(99)
R. Cayapas	3,756	994/3,346	(30)	1,966/3,397	(58)	2,381/3,564	(66)
R. Onzoles	2,360	140/823	(17)	257/1,415	(18)	182/2,243	(8)
R. Santiago	2,411	230/1,316	(17)	451/1,389	(33)	775/2,208	(35)
R. Guimbi	250	29/169	(17)	15/171	(9)	31/213	(14)
R. Guimbicito	115	–	–	0/69	(0)	5/98	(5)
E. Maria	856	–	–	0/710	(0)	28/786	(3)
R. Bogota	916	1/82	(1)	1/93	(1)	14/860	(2)
R. Cachavi	217	–	–	–	–	7/193	(3)
R. Palavi	146	–	–	–	–	42/131	(31)
Q. Grande	53	–	–	–	–	7/41	(17)
R. Tululvi	129	12/37	(32)	20/48	(42)	60/113	(53)
Ferrocarril	1,711	–	–	–	–	114/1,566	(7)
R. Mataje	277	–	–	–	–	58/243	(23)
Satellite Foci							
R. Canandé	1,236	60/392	(15)	138/367	(38)	481/842	(57)
R. Verde	149	25/142	(22)	31/113	(28)	39/134	(29)
R. Viche	245	18/110	(16)	29/167	(17)	41/231	(17)
R. Sucio	495	19/220	(9)	48/347	(14)	57/476	(12)
R. Vilsa	178	–	–	7/57	(10)	3/73	(4)
R. Cojimies	182	1/172	(1)	3/161	(2)	–	–
South Santiago							
Santo Domingo	–	–	–	–	–	142/266	(53.4)
Lago Agrio [a]	–	–	–	4/861	(1)	–	–
Total	17,167	2,251/7,868	(28.6)	4,206/10.634	(39.5)	5,930/16,099	(36.8)

ex – examined; % have been rounded up.
a: surveyed in 1987.

that the disease has intensified in terms of an increase in prevalence rates and skin microfilarial densities in most of the Santiago focus and that onchocerciasis has dispersed to previously non endemic areas (Table VI, Fig. 2). The total number of people with the disease has now increased from 4,206 in 1986 to 5,930. It is apparent that the disease is actively increasing and has dispersed outside the province of Esmeraldas. The northern limit of the focus is uncertain because no surveys have been carried out in southern Colombia. It is possible that the focus extends into this region with the R. Micay as its most northerly point. This is because the vector there, *S. exiguum s. l.*, has a low host capacity relative to the Ecuador cytospecies (Shelley et al., 1990b; Tidwell et al., 1980), which could limit dispersal of the disease, whose prevalence rates have not increase over 10 years (Ewert et al., 1979).

The situation in Ecuador is now as follows (Figs 1, 2):

The Santiago focus has extended northwards along the northern tributaries of the Santiago river basin to the Rio Mataje on the border with Colombia. This has been the result of migration to this area by infected individuals from the southern part of the Santiago focus and possibly from the southern part of Colombia. The parasitological data indicate that active transmission is occurring at some localities. Surveys to determine the distribution of

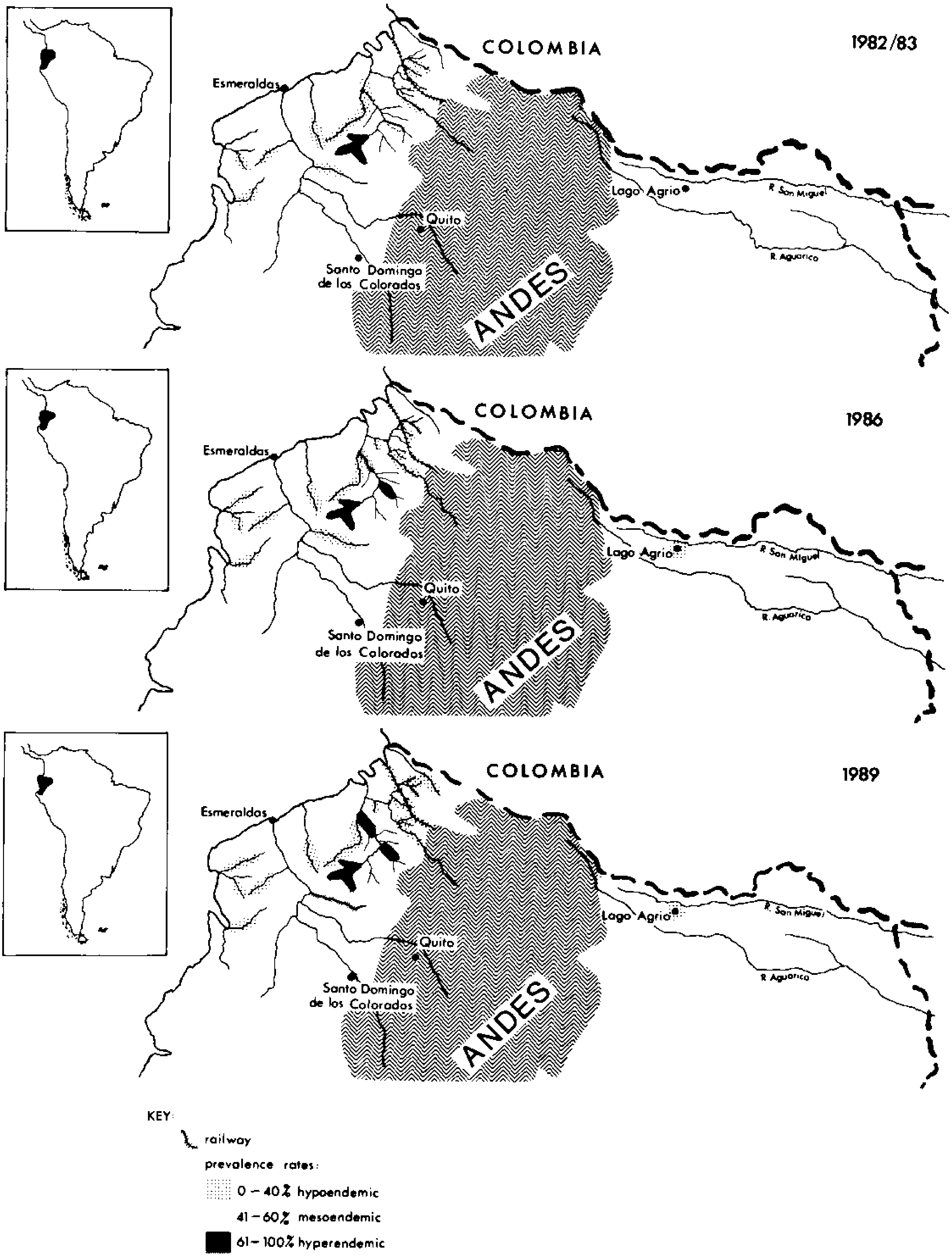

Fig. 2: prevalence and dispersal of onchocerciasis (1982/83, 1986 & 1989).

vector simuliids in this area and of *O. volvulus* in southern Colombia need to be carried out.

Onchocerciasis is present at localities along the railroad line from San Lorenzo to Lita. The railroad is the principal direct route to Quito from San Lorenzo and passes through the northern tributaries of the Santiago basin, where the recent surveys have shown the presence of

Fig. 3: human migration pattern from Esmeraldas onchocerciasis focus in relation to the distribution of the main vector, *Simulium exiguum s. l.*, in Ecuador.

onchocerciasis. Construction of the accompanying road has increased population movements in the whole region and inevitably aided the introduction of onchocerciasis into the area. Entomological surveys need to be carried out to establish whether vectors are present and whether active transmission occurs; *S. exiguum s. l.* has already been recorded at Lita. The development of this area and the already existing links with the mountainous areas around Quito increase the likelihood of the disease spreading to higher altitudes. Here, both *S. metallicum s. l.* and *S. escomeli* occur in high biting densities and could be responsible for the beginnings of new foci. It has already been shown in *S. woodi* of the *S. neavei* group in East Africa (Wegesa, 1966) and in *S. ochraceum s. l.* in Guatemala (Takaoka et al., 1982) that *O. volvulus* will develop at high altitudes with large temperature fluctuations, albeit at a slower rate. The host capacities of the two Ecuadorian species need to be investigated to verify this possibility.

The situation in all satellite foci except the Canandé seems to be stable. Although the simuliid fauna in these inaccessible lowland foci is not fully known, surveys in adjacent lowland forests have shown that the simuliid fauna is sparse and that the only anthropophilic species, *S. escomeli,* bites man in low numbers. It is therefore probable that *S. exiguum s. l.* is absent from the meandering lower reaches of the rivers on which the foci are found, and that they are below the critical altitude at which transmission can occur. However, in the forested area around the R. Canandé the disease is quickly intensifying and spreading because of the high bitting densities of *S. exiguum* Cayapa form. Development of this area will aid dispersal of the disease.

In the Santo Domingo area Chachi indians working on the African palm oil plantations are now known to be infected with onchocerciasis. Although local Colorado indians sampled were not infected, *S. exiguum s. l.* occurs in the area and will produce an active focus in time.

Onchocerciasis has now been confirmed to the East of the Andes at Lago Agrio. Although only zoophilic species of simuliids breed in the streams in the area *S. exiguum* Aguarico form occurs in the main rivers. The Aguarico form is probably an efficient host to *Onchocerca volvulus* but further work is needed to establish its vector capacity before the likelihood of transmission occurring can be assessed (Shelley et al., 1990b).

Figure 3 shows the migration trends of people in northern Ecuador in juxtaposition with the distribution of the primary vector *S. exiguum s. l.* and indicates the danger of onchocerciasis dispersing to other regions of Ecuador. Further surveys on the distribution and vector capacities of *S. exiguum* cytospecies are needed to predict more accurately the dispersal of onchocerciasis.

Control of onchocerciasis in Ecuador – Urgent consideration is needed by the health authorities to begin to monitor the disease and its vectors and take measures to implement its control. The principal onchocerciasis control measure in Ecuador should be the use of ivermectin because of its efficacy, low cost and ease of administration. Ivermectin treatment was started in communities on the R. Santiago in 1990 and its acceptance had been universal (Guderian, unpublished data). However, experience from other countries shows that treatment can never be complete with a relatively high proportion of the population remaining untreated for medical or other reasons (Duke, 1990). Also the success of the chemotherapeutic method is bound to diminish on the second round of treatment in 1991, particularly when consideration is given to the semi nomadic behaviour of some of the individuals affected. Chemotherapeutic measures alone will, therefore, still leave a proportion of untreated individuals, whose number will increase with the immigration of infected Colombians to the area. The presence of *O. volvulus* and high host capacity of the vector will lead to continuing transmission of the parasite in localities where fly biting densities are high (Shelley, 1991). Thus, in Ecuador, chemotherapy, with vector control at appropriate localities, will probably be necessary to reduce the disease to a low level of public health importance.

CONCLUSIONS

Data are presented on surveys carried out in 1989 in the Santiago onchocerciasis focus, satellite foci and localities to where the disease is thought to have dispersed since the last surveys in 1982/83 and 1986. The number of infected individuals has steadily increased from 2,251 in 1982/83 to 4,206 in 1986 and 5,930 in 1989. In the Santiago basin the disease has dispersed to northern tributaries through migration of infected individuals from the mesoendemic and hyperendemic areas of the southern tributaries and from southern Colombia. The disease was also detected at localities between the northern tributaries of the Santiago and the Colombian border as well as along the railroad line from San Lorenzo to Lita that traverses the focus.

Prevalence rates and skin microfilarial densities had increased in most communities that were mesoendemic or hypoendemic for onchocerciasis in 1986 probably as a result of the high vectorial capacity of *S. exiguum*. Prevalence rates and skin microfilarial densities had only increased at one of the satellite foci (Rio Canandé) where *S. exiguum* Cayapa form in an efficient vector with infectivity rates of up to 1%. Onchocerciasis had also dispersed to oil palm plantations south of the Santiago focus and to an oil field to the east of the Andes, through the migration of infected individuals. It is concluded that the disease is expected to disperse further to other areas because of migration of infected individuals and the widespread distribution of the main vector *S. exiguum*. Administration of ivermectin should be the mainstay of a control programme augmented by vector control in areas of high biting densities of *S. exiguum*.

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