The Control of Schistosomiasis in Patillas, Puerto Rico

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ONE of public health's most complex challenges to physicians, biologists, and sanitary engineers is the control of parasitic diseases in the tropics. Two classic examples are the campaigns against yellow fever and malaria in the Caribbean during the first half of the 20th century. More recently, the battle in the Americas has turned to the persistent debilitating disease, schistosomiasis mansoni, spread by the aquatic snail *Biomphalaria glabrata* in Brazil and Venezuela as well as in Saint Lucia, Puerto Rico, and other Caribbean islands. To learn whether *B. glabrata* could be controlled to halt the transmission of schistosomiasis and to determine the cost of such a project, the Puerto Rico Department of Health and the San Juan Laboratories of the Public Health Service instituted a control program in Patillas, P.R.

The history of the project can be divided into three phases. The exploratory phase, 1952 through 1953, included the initial prevalence surveys and attempts at chemical control of the snail. From the experience gained in that period the control phase, 1954 to 1960, was organized. By the end of 1960, the efforts in Patillas were reduced to the third or maintenance phase because of the scarcity of snail populations.

Manuel Pérez Torres and Félix García, of the Puerto Rico Department of Health, developed much of the original planning and organization of this project. Emilio Avila, of the same department, directed the daily field operations in Patillas.

Materials and Methods

The political boundaries of the municipality of Patillas coincide with the watersheds of the Patillas River and two small rivers to the east (figs. 1 and 2). The Patillas River starts at 700 meters above sea level in the central hills of Puerto Rico and runs south into an irrigation reservoir at an elevation of 67 meters. Average discharge into the reservoir is about 2 cubic meters per second. The initial reach of the river

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This paper is based on one presented by Dr. Ferguson at the meeting of the American Society of Tropical Medicine and Hygiene in Atlanta, Ga., October 1968.

is steep, but after leaving the reservoir the river flattens out considerably in the sugarcane area along the coast, continuing past the town of Patillas and then to the Caribbean. There are 200 kilometers of streams and 21,000 square meters of still-water habitats in addition to the reservoir, which has an area of 1.3 million square meters. An irrigation canal from the reservoir supplies water to the canefields west of Patillas.

Following the classic approach of centralized administration for control of vectorborne diseases, the field crews in Patillas as well as those in five nearby municipalities were directed by a project chief with his technical advisory group of biologists, sanitary engineers, and physicians. During the control phase of the project, a supervisor and five laborers with a vehicle worked full time in Patillas on the control of schistosomiasis. Sodium pentachlorophenate (NaPCP) at 6 milligrams per liter of water was applied to flowing streams for 24 hours; a V-notch weir was used for streamflow measurements. The chemical dose was regulated by a constant-head tank connected to drums containing 200 liters of NaPCP solution (fig. 3). In 1958 an automatic dispenser was introduced to decrease the amount of labor required for treatment of streams (*1*). Still water was treated with hand sprayers and briquets at a concentration of 10 milligrams of NaPCP per liter of water. Small seepage areas and swamps were drained by constructing ditches. Biological control was used also by planting *Marisa cornuarietis*, a predatory ampullarid snail, in the reservoir, which was too large for chemical control.

Although snail control was the major method employed during the control phase, routine but unevaluated treatment with stibophen (Fuadin) was given to more than 1,500 persons by the medical staff at the Patillas Health Unit of the Puerto Rico Department of Public Health. Health education was offered in the primary schools and rural communities. Drainage work was continued during the maintenance phase after 1960, but very little molluscicide was needed. Fuadin therapy was discontinued during this period because of poor results, and health education efforts were gradually reduced.

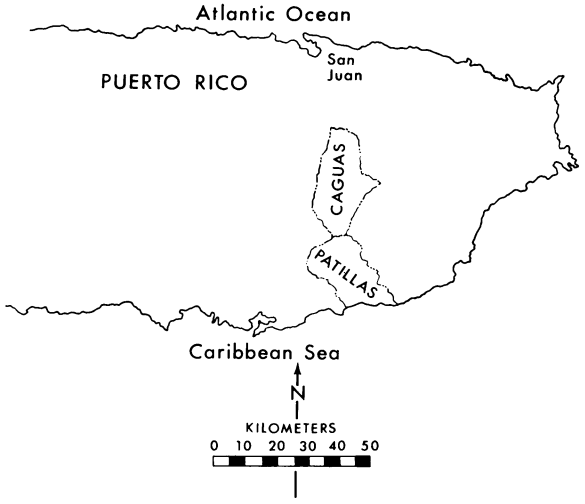
Prevalence of the disease and the effect of the program were evaluated from the annual survey in November of each year. Single stool specimens were collected from all first-graders; prevalence of *Schistosoma mansoni* eggs was determined by using a formalin-ether concentration technique (*2*). In addition to the annual survey in Patillas, a similar survey was conducted in the adjacent municipality of Caguas, where no control work had been done (fig. 1).

Results

Although populations of *B. glabrata* existed in 1952 throughout Patillas, by 1960 these snails were eliminated except for occasional colonies slightly upstream of the Patillas reservoir in the borough of Mulas (fig. 2). About every 2 years after 1960, snails appeared upstream of the reservoir and were killed with molluscicides during the dry spells when the river discharge dropped below 100 liters per second. *M. cornuarietis* became well established in the reservoir, and *B. glabrata* subsequently disappeared.

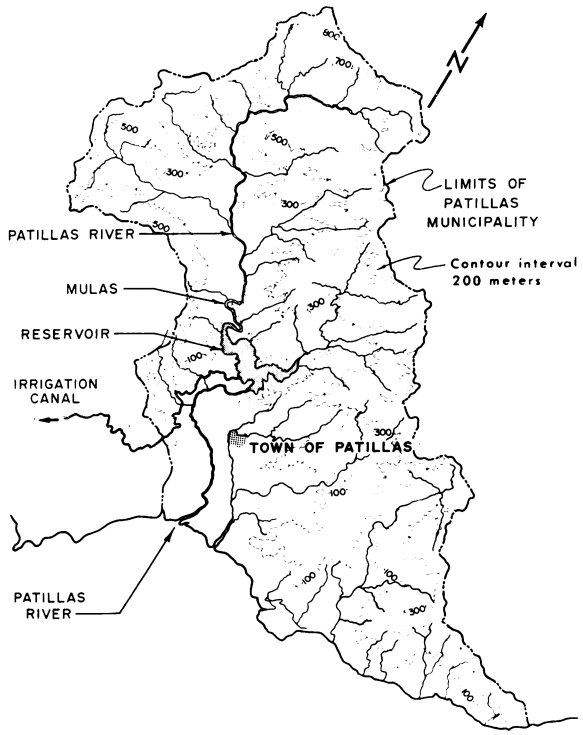
The prevalence rates used to evaluate progress in controlling transmission of the disease are presented in tables 1 and 2. Prevalence among 6-year-old children was originally slightly higher in Caguas (9.6 percent) than in

Figure 1. Location of municipalities of Patillas and Caguas in Puerto Rico



Location	1960 population	Annual rainfall (cm.)	Area (km.²)
Puerto Rico	2, 349, 544	175	8, 900
Patillas	17, 106	179	122
Caguas	65, 098	178	150

Figure 2. Major water bodies and topography of Patillas, P.R.



Patillas (7.7 percent), but the prevalence in 7-year-old children was greater in Caguas (13.8 percent) than in Patillas (11.5 percent). By 1960, when full-scale control efforts ceased and maintenance crews continued searching for snails, prevalence rates were still slightly higher in Caguas (3.2 percent in 6-year-olds and 4.4 percent in 7-year-olds) than in Patillas (0.4 percent in 6-year-olds and 1.4 percent in 7-year-olds). Moreover, the few cases of schistosomiasis detected in Patillas after 1960 were all from the single problem area of Mulas, where sporadic reappearance of *B. glabrata* occurred for several years. Despite rapid socioeconomic progress in Caguas, an increased prevalence was observed in 1966 as compared with the initial downward trend after 1953. Zero prevalence continued in Patillas among 7-year-olds.

During the control phase, the cost for snail control averaged $8,600 annually (table 3). In 1958, a typical year, the major expenses included 61 percent for wages; chemical costs were only 6 percent of the total. In the maintenance phase, about $4,000 was spent annually on inspections for the reappearance of snails and on the annual prevalence survey among first-grade school children. Maintenance costs also reflected the effect of a general salary raise among project personnel in the early 1960's.

Discussion

The successful measures for snail control strongly supported the long-awaited campaign to eliminate schistosomiasis from all of Puerto Rico. The drop of prevalence to near zero among the children was very gratifying. Clearly, schistosomiasis was no longer a public health problem in Patillas. However, the scientific value of the work was obscured by the parallel decline of schistosomiasis in Caguas, the untreated area. Many unexpected factors apparently were operating in Caguas that were not present in Patillas, such as rapid urbanization and economic improvement (*3*).

The first successful control of schistosomiasis in Puerto Rico was carried out on Vieques in a shorter period and at a lower cost than for the Patillas project (*4*). The principal method in both projects was control of the snails with NaPCP, and the comparative suitability of the two areas for snail habitats probably accounts for the differences in response to control. Vieques is relatively dry, with only 115 centimeters of annual rainfall, or about 64 percent of the

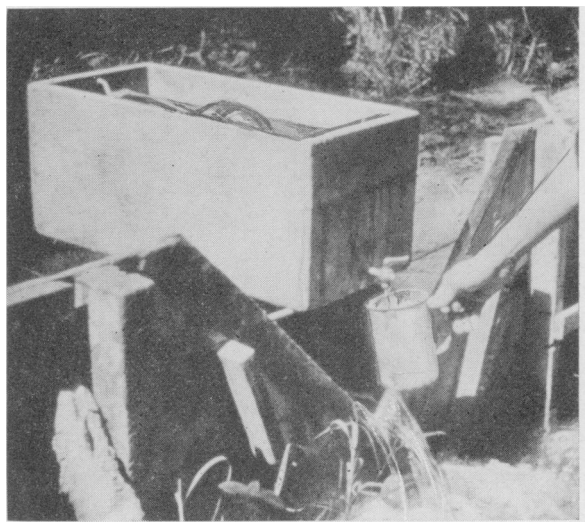


Figure 3. Inspector calibrating discharge of sodium pentachlorophenate from constant head dispenser into flowing water at V-notch weir on a small stream in Patillas, P.R.

annual rainfall in Patillas; also the topography of Patillas is flatter and provides more habitats for snails.

When the molluscicide treatment costs were calculated on the basis of cubic meters of water treated, the difference between those for Vieques and those for Patillas was very slight. No measurements of the volume of water treated were recorded, but costs were estimated from the amount of chemical used. Most applications involved standing water, which was treated at 10 milligrams of active ingredient per liter of water. About 89,000 cubic meters of water were treated each year in Patillas during the control phase at a cost of $9.70 per 100 cubic meters. These costs were slightly higher than those for

Table 1. Prevalence of schistosomiasis mansoni in first-grade school children in Patillas, P.R., 1952–66

Year	6-year-olds [1]			7-year-olds [1]		
	Total sampled	Total positive	Percent positive	Total sampled	Total positive	Percent positive
1952	122	9	7.4	219	47	21.5
1953	182	14	7.7	192	22	11.5
1954	203	13	6.4	186	17	9.1
1955	105	4	3.8	133	10	7.5
1956	222	8	3.6	106	4	3.8
1957	155	3	1.9	146	2	1.4
1958	209	4	1.9	210	6	2.9
1959	194	3	1.5	172	6	3.5
1960	227	1	.4	212	3	1.4
1961	233	1	.4	217	4	1.8
1962	249	1	.4	194	0	0
1963	262	1	.4	162	2	1.2
1964	285	3	1.1	137	1	.7
1965	302	0	0	144	0	0
1966	340	2	.6	149	0	0

[1] The 6-year-old population in 1960 was 574 and the 7-year-old population was 589. Source, reference 3.

NOTE: All results are from single stool samples.

Table 2. Prevalence of schistosomiasis mansoni in first-grade school children in Caguas, P.R., 1953–66

Year	6-year-olds [1]			7-year-olds [1]		
	Total sampled	Total positive	Percent positive	Total sampled	Total positive	Percent positive
1953	94	9	9.6	145	20	13.8
1954	274	31	11.3	246	25	10.2
1955	288	19	6.6	444	52	11.7
1956	504	31	6.2	791	78	9.9
1957	590	32	5.4	372	20	5.4
1958	525	26	5.0	354	23	6.5
1959	246	10	4.1	269	7	2.6
1960 [2]	663	21	3.2	497	22	4.4
1961	727	16	2.2	563	15	2.7
1962	831	13	1.6	381	14	3.7
1963	1,079	14	1.3	444	19	4.3
1964	1,147	6	.5	245	3	1.2
1965	1,302	7	.5	396	5	1.3
1966	1,425	17	1.2	406	9	2.2

[1] The 6-year-old population in 1960 was 1,728 and the 7-year-old population was 1,795. Source, reference 3.
[2] Figures corrected from data in reference 4.

NOTE: All results are from single stool samples.

Table 3. Total costs during the control phase of the schistosomiasis program in Patillas, P.R., 1954–60

Year	Project expenses [1]	Cost of NaPCP [2]
Total cost	$60, 383	$6, 199
1954	5, 643	979
1955	8, 760	1, 558
1956	9, 404	1, 058
1957	9, 026	913
1958	10, 500	613
1959	8, 803	725
1960	8, 247	353
Average annual cost	$8, 626	$886

[1] Project expenses included all costs for the full-time supervisor and laborers working in Patillas, as well as vehicle, equipment, chemical, maintenance, and travel costs.

[2] 83 cents per kilogram.

Vieques ($8.50) and much higher than the costs ($1.22 per 100 cubic meters) for NaPCP application for schistosomiasis control in Egypt (*4*, *5*). Treatment costs in Puerto Rico were higher than those in Egypt primarily because of higher labor costs.

Since Patillas has the same average rainfall as all of Puerto Rico, the cost figures should be more reliable than those from Vieques for projecting the cost of an islandwide program for snail control. By comparing the ratio of land mass of Patillas to that of Puerto Rico (fig. 1) and multiplying this factor by the total cost of the control effort (table 3), the estimated cost for the control phase of an islandwide program totals $4.5 million—assuming that the characteristics of Patillas are representative of Puerto Rico and that the control methods are similar to those used in Patillas. Adjustments to this factor should be made for the use of better molluscicides and for the higher costs of wages and materials. With this consideration in mind, the experience in Patillas offers a useful cost estimate for controlling schistosomiasis in Puerto Rico in the near future and marks an important step in progress against schistosomiasis in the Caribbean.

Summary

A joint effort of the Puerto Rico Department of Health and the San Juan Laboratories of the Public Health Service to control schistosomiasis in Patillas, P.R., was started in 1952 as an interdisciplinary effort involving biologists, engineers, and physicians. Snails were controlled with a molluscicide, sodium pentachlorophenate, or by drainage of snail habitats. Fuadin chemotherapy was given to children.

By 1962 the prevalence of schistosomiasis among 7-year-old children in Patillas decreased to zero from the original 21.5 percent in 1952, and the snail population was virtually exterminated. The successful program in Patillas, at an average yearly cost of $8,600, provided an estimate of less than $5 million for the snail control phase of an islandwide program in Puerto Rico.

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Tearsheet Requests

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