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?THE ECOLOGY OF BILHARZIA AND

AGRICULTURAL DEVELOPMENT IN PUERTO RICO

DURING THE TWENTIETH CENTURY

by

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in Puerto Rico during the twentieth century

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The history of tropical diseases in the Caribbean has been

unusually dynamic, alternating di:

trous epidemics with out-
standing successes in disease control, often related to man's efforts at modifying his geographical or agricultural limitations. One thinks immediately of the yellow fever and malaria outbreaks during attempts by the French to dig an isthmian canal in 1880, followed in quick sucession by elimination of yellow fever from Havana, Cuba after the Spanish-American War and then from the Panama Canal Zone. These dramatic upheavals were accompanied by other, less noticed changes such as the slow recession of hookworm infections, and the stealthy spread and collapse of endemic zones of schistosomiasis in various Caribbean Islands, notably Puerto Rico (Figure 1). Schistosomiasis in Puerto Rico is of exceptional interest because it appears to be nearing extinction.

A wealth of epidemiological information was available on schistosomiasis in Puerto Rico since 1906. Various surveys showed geographical distribution of the infection, apparently influenced by several major programs related to development of

the island such

irrigation projects, water supply program

and rural community development schemes (Figure 1). It was the purpose of this report to link the various epidemiological

surveys with the other historical trends, and thus ascertain

the interplay of these forces on the rise and fall of this parasitic infection in Puerto Rico.

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?The geographical distribution of schistosomiasis infection apparently existed as several small foci at the turn of the century. In 1904 the disease was first described in Puerto Rico

by Dr. Isaac Gonzdlez Martinez

"AL descubrix nosotros, no hace mucho tiempo los huevos tSpicos y espiculados de 1a Bilharzia (mansoni) en las deposiciones de dos sujetos Jévenes, nacidos ¥ eriados en este pais, del cual jamés emigraron, y que desde hacfa meses venian padeciendo de enteritis disen- teriforme, quedé provado claramente que el terrible

verne de bilharz, salvando la barrera del Atlantico,
extendia su odioso dominio por las islas que rodean?el.
Continente Americano

"Tal vez investigaciones posteriores demuestren
genbien que el mismo Continente no escapa a su fatal
influencia, dadas sus miltiples y f4eiles commica-
ciones con?el Archipiélago Antillano. Pero hasta 1a
fecha, nosotros nada hemos visto publicado en tal
sentido, y creemos que nadie ha tenido la fortuna de
comprobarlo. Sea de esto éltimo lo que quiera, es lo
cierto que ias primeras observaciones auténticas de
Bilharziosis en Puerto Rico son las nuestras."

The data available since 1904 are not adequate to develop
a rigorous statistical analysis of the changes in prevalence
of the infection through time ané throughout the island. Fortu-
nately however, the changes seened to occur in rather obvious
and drastic ways, thus detailed information was not required to
detect these changes. Nonetheless this epidemiological

analysis had to be kept fairly simple, dealing only with the large scale changes, and the results should be regarded as largely qualitative.

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HOOKWORMS AND SCKISTOSOMES

The development of a hookworm control program in Puerto Rico at the beginning of the century provided a great deal of information on the distribution of schistosome infections as well, Parallel with public health efforts of U.S. Army medical personnel in Cuba and Panam, a massive program for hookworm control began in 1903 in Puerto Rico under the guidance of Dr. Bailey K. Ashford, including diagnostic surveys by fecal smears in most population centers on the island (1) Because Dr. Isaac Gonzalez Martinez, who first identified the schistosome eggs in fecal smears, also trained the microscopists working with Dr. Ashford, they were searching for the eggs of the schistosome as well as those of the hookvorm. In the first decade of the twentieth century low prevalences of schistosome infection were found in the towns of Mayaguez, Utuado, Aibonito and a higher level on Vieques Island (Figure 2).

Although the fecal examinations were not conducted a part of a randomized sampling program, they did cover most of the island, and the complete absence of schistosome infections in Guayama and many other towns indicated that the parasite was quite limited in its distribution at that time. In 1906, fecal samples from 600 people were examined for parasite eggs, at the Guayama Substation of the Anemia Commission. In these samples

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FIGURE 2

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eggs of many common parasites were found, but no schistosome eggs. By 1909 over 2600 persons had been examined at this substation and no schistosome eggs had been found in their feces (2). In contrast, fecal examinations in Vieques showed a 13% prevalence of schistosome infections during the same years, the highest value found anywhere in Puerto Rico at that time.

To set the historical references, yellow fever had been eliminated by this time from Havana, and was controlled in the Canal Zone in 1905, mainly due to efforts of Finlay, Reed and Gorgas. Malaria had been sharply reduced in cities where larviciding and drainage works vere inplenented, under the direction of Le Prince and others of the U.S. Army and the

Rockefeller International Health Foundation. (15).

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COFFEE TO suGAR

?There was a major agricultural shift in Puerto Rico about

1905 from coffee to sugar, due to changes in the world market conditions and because of american intervention in the island's economy after the american military invasion of 1898. The shift in agriculture was made permanent by construction of the South Coast Irrigation Systems which provided the necessary water to increase canefield yields to highly profitable levels. In 1895 the income from coffee had been $7.5 million, three times the income from sugar. By 1910, even before the irrigation systems were completely operational, the income ratio had reversed with @ sugar crop worth $23.5 million and a coffee crop worth less

than $6 million (2). This agricultural shift caused a general migration of the labor force from the coffee haciendas of the central mountains to the coastal sugar plantations (Figure 1) The subsequent agricultural and social upheaval was vividly Portrayed in the novel "La Vispera del Hombre" which described the growth of a boy to manhood during these early decades of american occupation (17).

The decrease in coffee cultivation seemed to assist the

efforts of the Anemia Control Commission to control hookworm,

since transmission required the moist, shaded hillsides of the

coffee plantation. The Commission treated over 300,000 of the

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million people living on the island in the first decade of the century. This campaign, as well as the increased use of shoes and boots, eventually resulted in the disappearance of hookworm anemia and dise:

, although light infections persist
even at present. In 1966 about 12% of the children in first
grade were infected with hookworm (19).

?Twenty years after the hookvorm campaign was completed,
a thorough study of the distribution of achistosomiasis was
conducted by Drs. Hoffman, Faust and others involved in the
establishment of the School of Medicine and Public Health
?Their surveys confirmed earlier findings but in addition they
discovered a new, major endemic zone, the South Coast Irrigation
System between Guayama and Patillas. Detailed investigations
within this area showed that the disease was more severe than
in other parts of the island, and it was closely Linked
to activities within the irrigation system which had been
constructed in 1914 (5):

?It was interesting to compare the low
infestation rate of millworkers generally with that

of the fieldvorkers of Colonia Vives (Guayama). This
may be accounted for by the different working conditions

of the former... .Fieldworkers who are active round

the various irrigation systems give histories of

irritation in exposed external parts of the body,

and some show advanced symptoms, as indicated by

ascites...0ne showed lesions which he claimed

followed irritation of this type; another, showing

evidence of marked ascites, said he had been a laborer

in irrigation ditches for?a long time, and recalled

skin reactions on many occasions after his daily

work..."

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The shift in crops had apparently caused a similar change in endemic disease patterns from the hookworm related to the coffee haciendas in the mountains, to the new problem, schistosomiasis, related to the irrigation and drainage systems of the coastal sugar plantations. Given the ecological Link between sugar and snails, it was not surprising that shortly after 1952 when sugar production reached a maximum of 1.4 million tons, schistosomiasis became of such pressing importance to the Department of Health that the firet control program was initiated in these same irrigated zones of Guayama and Patitles.

In addition to the discovery of the new endemic zone in the South, Hoffman and Faust found that several new foci bordered the urban centers of Rfo Piedras and Caguas. Also the classical focus in Utuado was shown to be a emall zone but with high prevalence, reaching almost 100% in chiléren

living along the river.

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EPIDEMIC IN GUAYAMA

In order to clarify the changes in prevalence of schistosome infections in the south coast irrigation district of Guayama during the past 70 years it was necessary to relate results from several diagnostic tests, on various age groups. Because the most common test previous to 1963 was demonstration of the presence of eggs from a single stool of six year old children, all of the surveys were interpreted according to this standard che approximate prevalence to be expected if a single stool had been examined from six year olds, using the formol ether concentration technique (9). This interpretation required estimation of the ratio of prevalence anong various age groups and the prevalence among six year olds. Although several Laboratory procedures had been used to locate schistosome eggs in feces, they all have been calibrated and it was fairly easy to reduce the data

to the common standard (Table 1).

Using the age equivalence factor and the diagnostic test equivalence factor, the results from 21 fecal surveys showed a marked rise and fall of infection, reaching a fairly stable plateau at 252 between 1930 and 1950. This high prevalence then declined to zero 12 years after the

initiation of control measures (Figure 3). The continuing

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decline of prevalence was confirmed from skin-test data on older children, decreasing to 5% skin test reactors in fifth graders by 1976, the rate of false positives expected in a non-infected population. In conposite the various prevalence surveys made between 1906 and 1976 indicated that in Guayana, the disease, which was originally almost non existent, was spread by the introduction of irrigation and that by conbin~ ing snail control with other methods, the infection rate was brought back to near zero and the disease disappeared as a public health problem. Although outbreaks of Schistosoma haenatobius have been reported in Africa, this information

is probably the first documentation of an epidemic of S

mansoni in a water resource development scheme.

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POST WAR TRENDS

In a survey of over 19,000 military recruits during the Second World War, the previous island wide distribution of infec-lon was confirmed with some additional information obtained on outlying axeas such as Lajas, Fajardo, and Naguabo (Figure 2, adapted from reference 6).

Several surveys in 1953 and 1954 pre-saged the beginning of a control program in the endemic zone along the South Coast. The combined results of these surveys indicated two changes from 1944. The Utuado and Mayaguez foci had definitely diminished and new endemic areas were appearing in the eastern lowlands,

probably due to the construction of rural communities known as

Parcelas, (Figure 2). As in previous surveys, the zone of highest prevalence was the irrigated coastal strip between

Patill

and Guayana.

?The causes of the reduced prevalence of disease in the

western portion of the island cannot be precisely defined but urban growth after the war probably caused reduction in snail populations, and the government sponsored water supply program was also probably important. No control measures had been instituted in these areas except individual chemotherapy.

The endemic foci in Aibonito and Caguas were not related to sugar cane or coffee, rather the specific transmission sites were small extremely poor settlements along streams on the fringes

of the cities. Probably the combination of large population

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centers and the locally flat topography were enough to pro-

vide the adequate mixture of snails and people to support

transmission, especially around homes with poor sanitation.

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such as Aibonito or Utuado.

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With this background ir is hardly surprising that the

first director of the bilharzia control program was not a

malacologist but an entomologist, Don Manuel Pérez Torres.

?The multi-faceted campaign for bilharzia control was

gradually widened to Vieques, Naguabo, Aibonito, and the

Lajas Valley by 1956. Because of the experimental nature

of these pilot project:

» they were evaluated annually in the
first decade of operation (9). The decrease in prevalence
among first graders following the initiation of control in
Guayama was dramatic evidence of the success achieved by

these simple methods (Figure 3).

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APPROACHING ERADICATION

An island-wide sampling program, using adult worm anti-
gen in a skin test on fifth graders in 1963, showed that the
control program on the south coast had dramatically reduced
the importance of this area (Figure 4), General decreases
around the urban centers of Rio Piedras and Caguas were pro-
bably due to elimination of lowlands and channelization of
natural streams as part of the urbanization process (11).

The general rise in relative importance of eastern Puerto Rico
was apparently due to the large number of rural communities
constructed in lowlands under the Land Reform program ini-
tiated in 1941,

The adjusted mean proportion of positive skin test reactor for the {sland was 24% in 1963, with only one small watershed near Castafier below 10%, The pilot control pro-grans had been operating for 10 years, thus the geographic distribution of infection in 1963 was already affected. The 1963 survey showed that the eastern portion of the island had the highest positivity especially the Rfo Grande, Luqui-Mo, Gurabo, Juncos, Las Piedras, Camuas, Aguas Buenas, San Lorenzo, and Naguabo municipalities. The next most important

tier of infected ar

were immediately East of the eastern focus (Fajardo) and on the western flank where the control

program had brought the prevalence down.

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FROM SKIN TEST SURVEYS,1963-1976

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LEGEND FoR PREVALENCE

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FIGURE 4

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a.

4m Leolated focus of fairly high prevalence existed in
the central mountains around Utuado, Adjuntas, and Jayuya,
This was one of the first foci of schistosomiasis discovered
on the island, noted in 1906 (1).

By the second skin test survey of 1969 the overall pro-
Portion of positive reactors had dropped to half of the value
observed in 1963 (13). One reason was the control efforts
of the Health Department but apparently another factor was
the extensive construction of water supply systems after the
War (21). Of all the socioeconomic changes occurring in this
period, improved water supply correlated the most strongly

with decre

6 in positivity (22). By 1969 the island wide
Proportion was 14%, with many watersheds below 10%, the lowest
being the Barceloneta and Manat{ area with 4% (Figure 4).

All watersheds showed relatively large decreases except for

Ponce which showed a slight increase and the Upper Yauco-

Castafier watershed which increased from 8% to 20%. Becaus

of the small number of people involved in this watershed,

this increase was not too important.

In the principal focus on the eastern end of the island,

the remaining municipalities with the highest positivity were

Piedras, Juncos,

veduced to a small pocket around Gurabo, L.

Humacao, Maunabo, and Yabucoa. Because of their high rank

in this survey, these areas were covered by an expanded snail

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control program in 1970, Positivity had decreased significantly in the original pilot projects which were then placed on a maintenance program to deal with the occasional resurgences of snails, while the supplemented crews expanded to the new zones. For the first time, a mean proportion of positive less than 5% was found, occurring in two areas in north central Puerto Rico (Figure 4). This proportion of reactors was previously considered the level of false positives to be expected in a non-endemic area (11).

The final survey in 1976 indicated another large decrease in positive reactors, with an island wide mean of 5.3% (14) The most striking result from this recent survey was the

large number of watersheds where the mean proportion of

ctors had dropped below 5% (Figure 4). This included two watersheds which had been covered by the Health Department Control Program (Patillas, Arroyo, and the watershed which

included Aibonito). In addition, this minimal proportion of reactors was found in the entire western tier of watersheds, in the Ponce watershed, and in a group of six watersheds in the central portion of the north coast. The only areas

west of San Juan which had more than a minimal proportion of reactors were the Yauco watersheds which remained at 10%-13% despite means in the surrounding areas of less than 6%. This

residual focus seemed related geographically to the six

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reservoirs supplying water to the Lajas Valley Irrigation systen.

The positivity in watersheds covered by the expanded control program had decreased more rapidly than in the surrounding municipalities, except for Naguabo which showed only a slight decrease from 15% to 10%. Slight increases in two north eastern watersheds were due primarily to increases in several parcelas along the coastal highway between Carolina and Fajardo (Figure 4). Thus the renaining center of positivity was a amall portion of the eastern end of the island, covering about 15% of the population and

about one fifth of the land area.

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RURAL COMMUNITIES .

Since the early 1960's increases in schistosomiasis were noted in many parts of eastern Puerto Rico where rural conmunies, called "parcelas" had been created by a government program to improve rural housing (11). This program originated in the Land Reform Act of 1941 and provides free land for housing and limited farming to persons who are otherwise unable to obtain

it. In most of 400 parcelas constructed since 1950, there were no schistosomiasis problems, but in those constructed on alluvial plains in eastern Puerto Rico where drainage was poor and rainfall was high, definite foci of schistosomiasis transmission were created (23).

The results of the 1976 survey indicated that the parcelas along the northeastern coast were the most important remaining foci of the disease, especially the parcelas of Monte Bello, Malpica, Fortuna, Casa Blanca, Pitahaya, Mata de Platano, Dolores

and others in the municipalities of Carolina, Rio Grande and Luquillo (Figure 1).

In addition to the endemic disease caused by the infections in people living in these parcelas, recent cases of acute schistosomiasis have been documented in residents of metropolitan San Juan who use this northeastern coastal area for fresh water

recreation (24). There are undoubtedly meny more individual

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cases which go unreported, since an improved highway along the coast has made this area easily accessible to almost a million people.

The present situation in Puerto Rico has changed significantly fron the classic picture of endemic schistosomia~sis described by Faust in 1934, In only a few small communities is there stable transmission, the majority of cases apparently coming from random sporadic exposures, thus the parasite population may be gradually decreasing in

number due to geographical discontinuities in the transmis-

ion cycle (25). When a resident of San Juan becomes infected by a dozen or 20 cercariae during a shrimp-hunting expedition along the northeast coast, those schistosones return with him to the city and are taken out of the endemic, trans~ mitting population. Hopefully the drug oxanniquine will

soon be approved for use in Puerto Rico making it possible

to treat the infected persons in the endemic areas. This final blow to the worm population will probably be sufficient to completely disrupt the cycle, leading to parasite eradication.

?The malaria parasite was eradicated from Puerto Rico

after the War, and it is quite likely that the schistosome can also be eradicated. A word of caution is necessay however, since Puerto Rico is not typical of the endemic areas

of Brazil and the Nile Valley. Control or eradication is

much easier in Puerto Rico since it is on the northern fringe of the tropical zone of transmission, thus temperature conditions barely allow the snail to survive. The neighboring island, Hispaniola, is the last habitat of the snail one proceeds northward, and Cuba has neither the snail nor the parasite. Furthermore it is clear from this historical review that most of the severe disease in Puerto Rico occurred in areas of artificial environmental modifications. Previous to introduction of the irrigation systems, the parasite infection seemed spotty and minor in extent.

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SUMMARY

A wealth of epidemiological information available on schistosomiasis in Puerto Rico made it possibe to trace historical trends in the distribution of the disease. Using a variety of diagnostic methods, many island-wide surveys had been made on the prevalence of the infection, including a final series of 3 identical skin-test surveys terminating in 1976. The various surveys were analyzed chronologically and the geographical distribution of the parasite was discussed in light of several major programs related to development of the island. From a few scattered foci present in the early twentieth century, the extent and intensity of the disease increased on the south coast after construction of

sugar irrigation systems in 1914, After 1953 this major endenic area was broughtunder control while a new endemic area was developing in the eastern portion of the island, due to creation of rural communities known as "parcelas". Tais increased transmission caused by the parcelas had been counteracted in other parts of the island after the Second World War by the widespread construction of water supply systems and by filling of wetlands and channelization of streams on the growing suburban fringes of the major cities. Finally an expanded snail control program of the 1970 covered most of the newer foci created by the parcelas,

except for a small area on the north coast, east of San Juan.

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By 1976 only about 100,000 persons carried the parasite, mostly children with asymptomatic infections. They Lived

primarily in the northeastern municipalities of Rio Grande and Luquillo, with isolated groups in the Naguabo and Yauco

areas, as well as scattered remnants throughout the clas-

sical endemic areas. Complete control of the disease should

be accomplished in a few years if the newer drugs become

available for wide scale use in Puerto Rico.

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REFERENCES

B. K. Ashford and P, Gutiérrez Igaravidez, Senate

Document 808 of the 61st. Congress, 34 session USCPO,

Washington, D. C. (1911).

B. K. Ashford, Collected Papers of Puerto Rico

Inst. of Trop. Med. & Hyg. 1 (1912).

W. A, Hoffman, Porto Rico Review of Public Health and

?Tropical Medicine. 3, 223 (1927)

A. Serra, Journal of Public Health and Tropical Médicine.

6, 91 (2930).

W. A, Hoffman, and E. C. Faust, Porto Rico Journal of

Public Health and Tropical Medicine. 9, 228 (1934).

T. H, Weller, Major?and G. J. Dammin Major, P. R. Journal

of Public Health and Tropical Medicine. 21, 125 (1945).

P. Waite, D. Pimentel and F. Garcfa, American Journal

Tropical Medicine and Hygiene. .6, 715 (1957)

J. F, Maldonado and J. Oliver-Gonz4lez, American Journal

of Tropical Medicine and Hygiene. 7, 386 (1958).

W. R, Jobin, Ferguson, F. Frederick and J. R. Palmer,

Bulletin of the World Health Organization. 42, 151 (1970).

J. F, Maldonado and J. Oliver Gonzélez, Bol. Asoc. Med.

PLR, 54, 133 (1962).

1. G. Kagan, H. Negrén Aponte, J. C. Arnold and F. F.

Ferguson, U.S. Public Health Service Publication.

91 (1966)

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J. F. Maldonado, Boletin de la Asociacién Médica de

Puerto Rico. 5, 339 (1967).

E, Rufz-Tibén, P. M. Cox, W. D. Clark and E. R. Greenberg

Boletin de la Asociacién Médica de Puerto Rico. 65, 170.

cas73).

H. Negron and?C. M. Nazario, (in press).

I. Gonzdlez Martinez, New Orleans Medical and Surgical

Journal. 69, 352 (1916)

P. L, Rice, The Caribbean: Its Health Problems, University

of Florida Press (1965).

R. Marqués, La Vispera del Hombre, Editorial Universita-
via, University of Puerto Rico, (1959).

R, Pico, La Nueva Geografia de Puerto Rico, Editorial
Universitaria, University of Puerto Rico, 460 (1975).

E. R. Greenberg and F. F. Ferguson, Boletin de 1a
Asociacién Médica de Puerto Rico..63, 208 (1971).

Reports of Puerto Rico Department of Health, Antimalaria
Program, (1942-1954).

R. M, Guzmin, Journal American Water Works Association
58, (1966).

M. M. Bhajan, V. Martinez, E. Rufz-Tiben and W. R. Jobin,
Boletin de 1a Asociacién Médica de Puerto Rico (in press).
L, Barnett Cline, W. T. Rymzo, R. A. Hiatt, W. B. Knight
and L. B. Durfn, Journal of the American Society of
?Tropical Medicine and Hygiene. 26-109 (1977).

J. K. Lipes and R. A. Hiatt, Boletin de la Asociacién
Médica de Puerto Rico. 69, 35 (1977).

25. W. B. Rowan, Bull. Org. mond. Santé, Bull. Wid. Hlth.

Org. 33, 63 (1965).