AN EPIDEMIOLOGICAL STUDY OF HOOKWORM DISEASE IN A RURAL COASTAL PLAIN AND A CITY AREA OF PORTO RICO

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INTRODUCTION AND DESCRIPTION OF AREAS STUDIED

The investigations of the epidemiology of hookworm disease in Porto Rico, which were carried on in the summer of 1930 involved studies of the climatic conditions, environment and habits of the people, and an estimation, by the egg-counting method, of the degree of human infection of the rural population groups in two areas of Finca La Sardinera, on the coastal plain near the town of Dorado. In the discussion to follow I shall call these two areas A and B. The extent and location of soil pollution was determined by a general survey, questioning of the people, and mapping of the polluted spots; soil infestation was studied by collecting soil samples from the contaminated places and isolating the hookworm larvae by means of the Baermann apparatus(1); some experimental control studies were also carried out. A third area, (Area C), representative of the poor sections of San Juan and Santurce was also studied in so far as time permitted.

The purpose of these investigations was to ascertain the hookworm situation of the rural coastal plain where conditions were as yet uninfluenced by the sanitation work and treatment of the public health department, and to compare the results with those obtained in the city area which was directly under the influence and observation of the public-health department, and with the previous results of other workers on the island and in other parts of the world. Based upon the information thus gained, a control program might be recommended which would reduce the prevalence of the disease to an unimportant level from the standpoint of public health.

The two areas, A and B, are on the same piece of land in the coastal plain. The soil is sand or sandy loam; numerous sandy roads exist for transportation; vegetation is abundant in practically all parts of the territory. More shade is found around the houses in Area A than in Area B, but there are bushes near the houses of

both areas. Coconut palms, grapefruit trees and herbs are the principal vegetation of Area A. Sugar-cane predominates in Area B, although around the houses some bananas and potatoes are grown. Shade, therefore, exists more or less generally throughout both areas. The total number of families on this land is 62,* twenty-five of which are living in Area A. The houses of both sections are more or less scattered, yet a few are as little as two hundred yards apart. Drainage is good, on the whole, around the houses and in the fields, and most dooryards are fairly well kept. The landowner built the houses of Area A which consist of two or three rooms, with wooden floors and walls, and grass roofs. The more primitive houses of Area B, on the other hand, were built by the inhabitants themselves. All the houses are well raised off the ground in both areas. Domestic animals, such as dogs, cats, pigs, chickens, appear around, under, and sometimes even within the houses.

Almost every house in Area A has a latrine nearby, while in Area B only fourteen houses have latrines.

The economic status of the people, in general, is poor. Taking the individual family income, in Area A, which is evidently higher than that of Area B, the average is not more than $7.50 per week. The food, which is typical of that of poorer Porto Ricans, consists of rice and beans, bananas, salt fish, and coffee without cream nor sugar. The water supply is taken from deep wells by wind power. The children of school age attend school and after school hours the majority of them help their parents on the farms or at home. As the women are engaged solely in domestic duties, the younger children are kept at home with them. The men are employed on the plantations from 7 A. M. to 5 P. M. whenever work is available. Most persons never wear shoes except on visits to the city.

A few of them had been treated for worms some years before at their former residences, but most of them had not had previous treatment for worms, although they had lived for more than three years in this particular place.

Area C consists of three representative city districts in Santurce (Seboruco, Monteflores, Trastalleres) and one in San Juan (Barrio La Perla). These four districts are about 25 miles from Areas A and B. About 500 individuals from more than 100 families were taken for the survey. Only 271 cases were examined. The economic status here is also poor, but living conditions appear to be somewhat better than in Area A. These people usually wear shoes, except the very young children. The chief source of employment

* Two families in Area B are omitted from the study in further discussion.

of the city people is found in tobacco-manufacturing, needle-work, store-keeping and peddling. Most of them had come from other cities of the Island and had not lived in these districts more than six years, rarely had it been their birth-place.

With one exception every house in Area C had been provided with a latrine by the owner. This area is under the rigid inspection and control of the public health department which maintains a system of health units under health officers and inspectors.

The temperature and rainfall of Area C, are practically the same as of Area A and Area B; the same sandy soil is to be found; and drainage is, for the most part, good. Here, however, the houses are very close together, and the yards are too small even for the children to play. The ground is hard-packed and it would seem that under such conditions even if a considerable amount of soil pollution existed it would not be possible for hookworm to develop naturally.

The climatic conditions in all these areas are favorable for hookworm development. The minimum temperature is never below 57°F. and the maximum temperature is between 80° and 99°F., with the mean monthly temperature between 70° and 80°F. The annual rainfall is about 70 inches. There are almost weekly rains, the minimum precipitation occurring in the spring, when in some months it may be little more than 1 inch. Rain falls no less than 9 days a month throughout the year, while there may be as many as 28 days of rain per month.

HUMAN INFESTATION STUDIES IN THE THREE AREAS

Fecal samples were collected from the inhabitants of Areas A and B with the cooperation of the landowner, and the collection work in Area C was greatly facilitated by the assistance of social workers and nurses from the health units. Through their help, histories were taken in all cases, a uniform blank being distributed for this purpose. Half-ounce tin containers with labelled covers were left with the families and every possible precaution was taken to prevent mixing of specimens in large families. Containers were distributed to only one large family at a time and careful explanations were made to the individuals. These containers were brought in on the following day and prepared in the laboratory for counting. Samples were easily obtained in Areas A and B, but some difficulty was encountered in Area C. This was perhaps due to the fact that no treatment was attempted in Area C, which accounted for the lack of interest of the people.

The method used in making the egg counts was that developed by Stoll(2) and used by Cort, Payne and Riley(3) in connection with epidemiological studies of hookworm disease in Porto Rico. In those cases occurring in Area C, where the stool samples were too small for this technique, examination was made by the Willis flotation or the simple smear method.

A total of 155 examinations was made in Area A. Samples were taken from 21 families and included 88 males and 67 females. Of these 116 or 75 per cent were positive for hookworm eggs, 85 per cent in the males and 61 per cent in the females. The positive cases had counts ranging from 50 to 417,000 eggs per gram. It is striking to note that of the 39 negative cases, 19 or 49 per cent were under 5 years of age and 13 or 33 per cent were under 3 years of age. Of the 116 positive cases, on the other hand, only 17 or 15 per cent were under 5 years of age, while only 8 or 7 per cent were under 3 years of age.

The average egg count for the 155 cases examined from Area A, was 4,710 eggs per gram (see Table I) with an average of 7,000 for the 67 females. These averages were corrected for a standard age and sex distribution, using the 1910 census of Porto Rico as was done by Sweet(4) The correct average for the whole group was 5,120 eggs per gram; for the males 7,490 and for the females 2,040 eggs per gram. This indicates that the age and sex distribution in this group does not correspond exactly with that of the standard population, because of a little higher percentage of children in the group under study.

For the purposes of analysis the data were divided according to natural groups: 0 to 4, 5 to 9, 10 to 14, 15 to 39, 40 and over (Table I). Various stages of activity were represented in the age groups of the children and adults. The youngest children were kept at home, the group from 5 to 9 of pre-school and early school age were not closely confined at home, while the activities of the group from 10 to 14 were not limited. Up to this point there appears little divergence on the activities of the two sexes. The males in the group from 15 to 39 labored on the plantations, and the females were occupied with the rearing of children and household duties. Finally, after the age of 40 both sexes remained more closely at home. Considering the total count of the female group it will be seen that it is noticeably lower than that of the entire group of males, which suggests that there exists a distinct difference in the extent of exposure of the two sexes to hookworm infection. This point will be discussed later.

A total of 217 cases was examined in Area B from 25 families including 116 males and 101 females. Of these, 191 or 88 per cent were positive for hookworm eggs, 91 per cent in the males and 84 per cent in the females, with counts ranging from 100 to 81,400 eggs per gram. There were only 26 cases negative, and of these negative cases 19 were under 5 years of age and 10 were under 3 years of age. On the contrary, of the 191 positive cases, 18 were under 5 years of age, and only 3 were under 3 years of age. The average egg count for the whole 217 cases was 7,060 eggs per gram, with an average for the males of 8,990 and for the females 4,830 eggs per gram. The correct average for the whole group was 7,050 eggs per gram, that for the males being 8,780 and for the females 4,810 eggs per gram. The age and sex distribution of the group was shown, therefore, to be quite typical of the standard population. The analysis of egg-count data which were obtained in this district was also made according to the natural age groups (Table I) in order that comparisons could be drawn with Area A.

The results of the examinations of 271 cases in Area C show only 72 cases, or 27 per cent positive for hookworm, of which 35 cases, or 31 per cent were male and 37 cases, or 23 per cent were female. The total cases examined by the Stoll dilution egg count method were 248, of which the average egg count was 620 eggs per gram; the total cases of males examined were 105, with an average egg count of 550; total cases of females examined were 143, with counts of 670 eggs per gram (Table I).

The acquisition rate of infestation in the children of Areas A and B is shown in Graph I which gives the percentage of infestation of the children in terms of the average for adults (15 years and over).* In Area A these results show that by the age of 7 the children have more than half of the adult egg count, and that by 11 years it is not far below the adult average, while in Area B the maximum rate of acquisition is found to be in the years 12 to 14 which is higher than that of the adult group.

The greater infestation of the adult males as compared with the females in Areas A and B, as shown in Table I, may be explained by differences in activities of the sexes. While the men of Area A were engaged in work in the coconut and grapefruit groves and in the general upkeep of the plantation, those of Area B were employed in the sugar-cane fields, some of which were near the houses and others

* Here it must be noted that the count in children is exaggerated on account of the small stool. In the series considered by Stoll(6) the stools of children under three years of age were ¼ and those between three and five years about ½ the size of the adult stool.

were more distant. In both areas concentrated soil pollution and soil-infestation spots abounded in the fields where the men worked, and it is logical to assume that a part of the male infestation was due to habitual exposure to such places. Moreover, as pollution spots were found also in the bushes close to the houses they furnished a double opportunity for exposure to the men but were practically the only places of exposure for the women.

On comparison of the infestations of the natural age groups (Table I) in Areas A and B, the analysis shows that there is no noteworthy difference between the infestation of the males and females in the group 0 to 4, although the average eggs per gram of the males in Area A is more than twice that of the females. This was accounted for by the egg count of one male which almost equaled all the other counts added together. If this case be discarded, the male average would be only 960 eggs per gram. Likewise, in Area B, the case of a four-year-old boy, whose count was 6,140, gives the males an average higher than that of the females. If this count were struck out, the male average would be only 950 eggs per gram, making it only slightly higher than that of the females. A definite divergence appears between the sexes in the groups 5 to 9, 10 to 14 and 15 to 39, but the number of cases of 40 and over is too small in both areas for a conclusion. Presumably, there is little difference in the activities and habits of the two sexes in children under 5 years. Thus there is approximately an equal chance for infection among them. It is difficult to explain why there should be as much difference as there is between boys and girls of pre-school age, though it may be due to the fact that the girls defecated in containers in the houses more frequently than boys, who begin at an early age to visit the pollution spots used by the adults. Among the school age group a definite difference of habit was evident as in the case of adults, as the girls remained at home and the boys took up work in the fields, assisting their fathers or older brothers.

Area C was found to have an average of only 620 eggs per gram for the 248 cases examined by the egg-counting method. Most of these showed only light infestation with an incidence rate of 27 per cent. Such an infestation can not be considered of medical importance. Only one case had a count high enough for clinical attention, which was 37,700 eggs per gram. The infestation of this area, therefore, is not regarded as a clinical and public health problem, since these people, living in the city and its suburbs, as a whole, have latrines or sanitary toilet systems which gave evidence of being in use. Moreover, this section is under the rigid inspection of the

health authorities. Furthermore, the city conditions, *per se*, would no doubt have kept down the infestation, as the hard-packed soil around the houses and in the yard is not favorable for the development of hookworm larvae even if soil pollution existed. In other words, Area C does not present a hookworm problem.

In summarizing the conditions in the three areas, it may be seen that the degree of infestation and incidence rate are high in both sexes in Areas A and B and are deserving of medical and clinical attention. It has been remarked that the male infestation is higher than that of the female in degree and incidence rate, and has been accounted for by the wider range of the activities of the men. The infestation in Area C is negligible as a question for the public health department, due to the sanitation practised under the strict enforcement of the health authorities, and to the unfavorable soil conditions of the cities.

The prevalence and intensity of hookworm infestations were disclosed by this study to be greater in Area B than in Area A (Table I). It is not until the children reach the age of 10 to 14 that any considerable difference is noted. When the heaviest cases are analyzed Area B has 12 cases with more than 30,000 eggs per gram, while Area A has only 4 such cases. It is safe to assume that there exists a correlation between the habits of the people and the extent of hookworm infestation, and from the egg counts it seems evident that sanitation in Area B must be somewhat below that of Area A.

SOIL-POLLUTION AND SOIL-INFESTATION STUDIES

The soil pollution and soil infestation studies in Area A were begun early in June 1930. I should like to emphasize here that according to the information of the landowner all the houses in this area have been provided for many years with latrines which were built at the same time as the houses. Following the hurricane of 1928, which destroyed all the houses and latrines of this area they were all rebuilt. Nevertheless, the fact that the people of Area A had a rather high egg count suggests that this type of sanitation has not been successful in controlling hookworm.

The soil pollution and soil infestation studies in Area A were carried out about a month and a half after the first egg counts and after an educational campaign had been completed. I presume that the difficulty experienced in finding soil pollution and soil infestation may be laid to the fact that the people had been more or less influenced by this sanitation campaign.

The latrines constructed in this area had pits, which were more

or less deep, some of them about two feet and some as deep as five feet; the vaults were made of wood; the seats were wooden boxes with covers; the roofs were made of zinc and some of them possessed ventilation stacks. House No. 5 was the only one of the 20 houses studied in Area A where the latrine was not in use. Signs of pollution were seen or suspected in 11 of the 20 houses visited in this area, either in the woods nearby or in the dooryards. The dooryard pollution could be attributed to the young children. Some grapefruit and one coconut groves were studied, and only one grapefruit plantation showed old signs of pollution in the vicinity.

At nine houses out of the 11 positive houses, only a few soil pollution spots were visible, while the remaining two houses showed a great amount of soil pollution. However, after the first few days of my survey, the people became conscious of the unsanitary conditions in which they were living and began to take better care of their latrines, and even covered the stools with sand or coconut shells or cultivated the habit of always using the latrines. It was very evident, therefore, that where the latrines had been introduced and an effort made toward their habitual use, the soil pollution habits of the people had been considerably overcome. In rare instances, soil pollution spots were seen at the side of the sandy road beds.

The soil pollution and soil infestation investigations in Area A were carried on simultaneously. A total of 40 soil samples were collected from around the houses and dooryards of 20 houses in Area A. Of these only four samples were found to be positive for hookworm larvae, with a total of 30 larvae, indicating that practically no soil infestation existed in the dooryards of the houses. The cases in which infective hookworm larvae were found might be explained by the presence of polluted spots made by the children or by the scattering of feces by chickens and other animals. The soil samples taken from the pollution spots in the woods or bushes from 10 different houses, disclosed only one place, House No. 5, where infective hookworm larvae were present in large numbers (225 in three samples); eight other houses showed only a few larvae and one house was negative. Only 11 out of the 20 houses studied were found to have soil infestation in one or more places in the vicinity of the house. Only about House 5 was the soil infestation heavy. The soil pollution and soil infestation of two grapefruit groves were studied and only a few infective hookworm larvae were discovered.

The question of slight soil infestation in the face of the heavy human infestation of Area A may be explained by the fact that educational films and lectures had recently caused the inhabitants to

discontinue more or less their soil-pollution habits. The vigilance of the landowner and the manager of the land would account in some degree for the disappearance of soil-pollution evidence. The conclusion to be drawn here, is that while the previous unsanitary conditions had been improved by the campaign, those conditions had, however, been responsible for the present heavy human infestation. The fact that latrines had been built but were not consistently used, suggests that the existence of latrines alone, will not control hookworm disease if the people do not realize their importance in connection with the disease.

Area B was studied, also, for soil pollution and soil infestation about one month after Area A. The environs of this area have already been described and there is no need to review them, except to recall that the amount of shade around the houses is less than in Area A. Of the 35 houses* investigated 14 had latrines, all of them in bad condition, yet all appeared to be more or less in use. The feces, however, were scattered about the yards. These latrines had been constructed not longer than a year, and one would not expect to find the human infestation much modified in so short a time. Distribution of soil pollution was affected by the fact that so many bushes and sugar-cane fields surrounded the houses providing defecating places. Children tended to pollute the yards and their stools were often scattered by domestic animals as was the case in Area A. Pollution spots visited by adults were found at a number of places in the bushes close to the houses, and in the neighboring sugar-cane fields. In these places the stools were more or less concentrated and they were well shaded. The soil was damp, as the moisture from the very frequent rains was retained in the shade. Such an environment was very suitable for the development of hookworm larvae.

Fairly heavy soil infestation appeared in the 51 soil samples which were taken from the polluted spots in the sugar-cane fields and about the 15 houses surveyed. Soil infestation was examined around the latrines and in the dooryards and only a small number of infective hookworm larvae was found, confirming my observation that those places were unfavorable because of lack of shade, and because such pollution spots as were seen were made by the young children whose infestations were comparatively light. After a rain such places dried out very quickly. These results justify the conclusion that the sources of human infestation in Area B are those pollution spots in

* Two families were omitted.

the bushes and sugar-cane fields in the immediate vicinity of the houses, and the existence of contamination in the dooryards is relatively unimportant in the infection of the adults, although it may be a minor factor in the light infestation of the children, especially during the rainy season.

From the investigation of the soil pollution and soil infestation of these two areas, it appears that the pollution of the soil among the bushes or under trees near the houses and in the adjoining sugar-cane fields, where there is more or less shade, is a common and long established habit of the people. It is in these places that infective hookworm larvae can be found, and to them can be attributed the heavy human infestation of both areas. As the soil pollution and soil infestation of Area A was found to be very much less than in Area B, I have assumed that the educational campaign preceding my epidemiological study was responsible for the increased sanitation of that area, although it is probable from the lower infestation that conditions there before this work was begun were not as bad as in Area B.

EXPERIMENTAL STUDIES

Some experimental work was carried out to discover the favorableness of the situations in this area where soil pollution was found for the development and persistence of hookworm larvae. Two types of soil were used as media for the cultures, sand which was usually found around the houses, and sandy loam of the type found in the grapefruit groves and sugar-cane fields. Cultures in these soils were placed in dense shade, partial shade, and direct sunlight. In the sandy loam cultures exposed to direct sunlight from 6 to 8 hours a day very few larvae developed in 7 or 8 days while in the sand cultures no larvae were found. A small percentage of the larvae, about 5 per cent of the eggs placed in the cultures, developed in the sandy loam in the partial shade, and a still smaller percentage in the sand cultures. In the dense shade there was fairly good development in both sandy loam and sand although in both cases we obtained a smaller percentage than reported by other workers for similar conditions. This may be explained by the fact that the cultures were placed under as nearly natural field conditions as possible. These experiments, although very limited in number, give an idea of the possibilities of development of hookworm larvae from soil pollution in the different types of situations found in the areas studied.

Experiments on the length of life of hookworm larvae under the conditions of the areas studied agreed very closely with those carried

on by Augustine(6) elsewhere in Porto Rico. It was found that in the shade the number of larvae were reduced by over 50 per cent in 17 days and by 73 per cent in 24 hours. In moderate shade the reduction was almost 90 per cent in 8 days and practically all the larvae were dead after 24 days. In direct sunlight only a fraction of one per cent survived after 4 days and all were dead by the sixth day. The experiments supported the views expressed above that most of the infestation in the people was obtained from the shade pollution spots among the bushes and in the sugar-cane fields, rather than from the dooryards.

COMPARISONS OF THE EPIDEMIOLOGY OF HOOKWORM INFESTATION IN THE AREAS STUDIED WITH OTHER INVESTIGATIONS IN PORTO RICO AND OTHER PARTS OF THE WORLD

An attempt was made to compare the epidemiological results on hookworm disease in the areas studied during the summer of 1930, with the work of others on the Island, and with that done in some other parts of the world, in order to understand the general problems of hookworm disease from which a system of control measures might be recommended.

Hill(7) gives an average count from Manatí which is situated a few miles inland from the coast. His average count based on 126 cases, was 4,920 eggs per gram, which is a little higher than the count I obtained in Area A. In all municipalities cited by Hill the infestation is greater in men than in women, with the exception of that in Moca, where the infestation of women was practically equal to that of the men, and in Adjuntas, where it was actually greater. This condition was explained by Payne, Cort, and Riley(8) as due to the fact that the women were exposed to even greater infection than the men on account of the gross pollution found in shaded areas close to the houses in the areas studied, as well as that found in the places where the women worked, particularly the coffee groves. Cort, Grant, Stoll and Tseng, working in China(9) give counts from 770 cases examined in the mulberry growing regions near Soochow, where the average count was 4,692 eggs per gram. In this series the females showed decidely heavier infestations, since the women did most of the work in gathering the mulberry leaves, thus increasing their exposure to hookworm, since the places of soil infestation were on the ground beneath the mulberry trees.

Payne, Cort, and Riley(8) studied an area (Area C) about 10 miles from Utuado which is in the central part of the Island. They found the average egg count to be 7,740 eggs per gram for 92 cases

examined. This count was only a little higher than that which I have given for Area B.

Hill,[7] in summarizing all the previous work in Porto Rico reported that the highest egg counts recorded up to that time were in the interior. Two such areas were Morovis, where an average of 8,270 eggs per gram was found in the 510 cases examined, and Adjuntas, where the average count among 86 individuals was 7,740 eggs per gram. At that time Hill also reported that the areas examined along the coastal plains showed a definitely lighter infestation. My results, in part at least, do not agree with his, as Area B in this study located on the coastal plain shows an average egg count of 7,055 eggs per gram for 217 cases examined, which is only slightly lower than that reported by Hill in the interior.

Payne, Cort, and Riley[8] found an average count of 630 eggs per gram for an area in Porto Rico which they examined two weeks after the last of a series of three oil of chenopodium treatments. This count corresponds with my average of 620 eggs per gram in Area C. This would indicate that the level of the infestation in Area C was about that which would be expected at the close of a treatment campaign.

The studies which I carried out on soil pollution and soil infestation in Areas A and B indicate certain striking similarities to the pollution spots reported by other workers in areas where the soil pollution was due to the defecating habits of the people, and not to the use of human excrement as fertilizer. Cort et al[3] found that the coffee groves of Porto Rico were widely polluted, as well as the areas close to the houses. A comparison was presented in Areas A and B, in my work, where most of the pollution spots were scattered in the bushes or in the fields near the houses. Very similar conditions were reported for Panamá and Trinidad by Cort[10] and his co-workers[11], where pollution conditions in the sugar-cane fields were almost identical with those which have been shown in Area B. I failed, however, to find any such "natural latrines" as were described in the cocoa plantations of Trinidad. In Malay, Siam, and the East Indies, Barnes and Russell[12], Barnes and O'Brien[13], and Chandler[14], respectively, reported similar conditions since in those countries soil-pollution practice was responsible for the promiscuous contamination of the soil. In China[9], on the other hand, there appears to be little or no soil infestation by the chance scattering of stools as in Porto Rico, but the custom of fertilizing with human excrement in certain field crops, creates definite cultures in

which hookworm larvae develop. Contact with such infested spots in connection with crop cultivation appears to account for most of the infection.

RECOMMENDATIONS FOR CONTROL WORK

Cort([15]) has pointed out that there is a vicious cycle in hookworm infested areas which may be outlined briefly as follows: "Human infestation and soil pollution, with a favorable environment, produce a soil infestation which, with human contact, produces new or additional human infestation". It would seem, then, that the control of hookworm would be a relatively easy matter involving only the breaking of the vicious cycle at some point. The practical application of this conclusion, however, is anything but simple as the economic conditions, education, and many other factors must be considered when an attempt is made to radically change even minor habits in population groups. Up to the present, the methods of hookworm control which are considered most economical and logical are "treatment and sanitation". By sanitation alone, hookworm infestation can be slowly reduced, while treatment alone reduces the infestation rapidly but reinfection occurs and the infestation tends to return to its original level. Both, therefore, in combination will permanently reduce the disease to an unimportant clinical level.

As a result of my survey in Areas A and B, I would recommend that the following control measures be carried out:

Area A. This area is already provided with latrines at each house. Presanitation has, therefore, already been carried on to some extent, for many years in this section, but the people still lack the proper understanding of the use of latrines and of maintaining them in good order. It is quite evident, from the high level of human infestation, that presanitation, though long established, had not been efficient in controlling hookworm infestation. Yet the lack of soil pollution at the time of the investigation shows what can be accomplished by such efforts as our presanitation work involved.

SUMMARY AND CONCLUSIONS

The methods used for epidemiological studies of the hookworm infection in Porto Rico during the summer of 1930 were as follows: first, general studies of the areas, climatic conditions, habits of the people and their economic status; second, estimation of the degree of human infestation by Stoll's dilution egg-count method; third, soil pollution surveys by questioning the people and mapping the polluted spots; and lastly, investigation of the soil infestation by

isolation of the infective hookworm larvae from the soil samples collected from the polluted places.

Areas A and B had soil, shade, and general climatic conditions which were practically the same, and were favorable to the development of hookworm eggs into the infective stage. Area A was considered partially sanitated, as every house had had a latrine for a long period, while Area B was almost unsanitated. The infestation of the men was found to be higher than that of the women both in degree and rate of infestation. From this it was inferred that the men's activities led to greater exposure to hookworm infection than the women's. Area A showed heavy infestation which was comparable to the results of the work of others on the coastal plain of this Island, while Area B can be compared, on the other hand, with the still heavier infestation of the interior. This indicated that both areas constituted a clinical and public-health problem, and the important sources of infection were the pollution spots which were located among the bushes near the houses and close to the working places. Dooryard pollution spots were not considered of very great importance as far as the sources of hookworm infection were concerned. The soil pollution and soil infestation localities, as observed, were not sufficient to account for the heavy infestation present in Area A. It is evident that the conditions of Area A had been much improved since the beginning of the educational work which preceded the survey. Furthermore, it was obvious that the presanitation work of the landowner in the past, providing latrines but not enforcing their use, had failed to control hookworm disease in this community. This condition was markedly improved after the people were made aware of the importance of using latrines to prevent soil pollution.

Area B has more infestation in both sexes than Area A in both incidence and degree, for which the following reasons may be given.

1. More persons in Area A wore shoes.
2. The pollution spots of Area A were confined to the bushes near the houses and away from the places of labor.
3. The females of Area A used the latrines more than did those of Area B which might account for the fact that the infestation was less in degree and incidence rate.

Area C had the same climatic conditions as those of the rural areas, but the soil and city conditions themselves were not favorable for the development of the hookworm larvae. The degree of infestation is very low and is not considered as a public-health problem.

Experimental studies for testing out the actual conditions of development of hookworm larvae were also carried out in places of varying shade. The results obtained seemed to confirm the soil pollution and soil infestation studies as well as the conclusion that the important sources of human infestation must have been those areas of pollution in the bushes around the houses and sugar-cane fields and not the dooryard pollution by the children.

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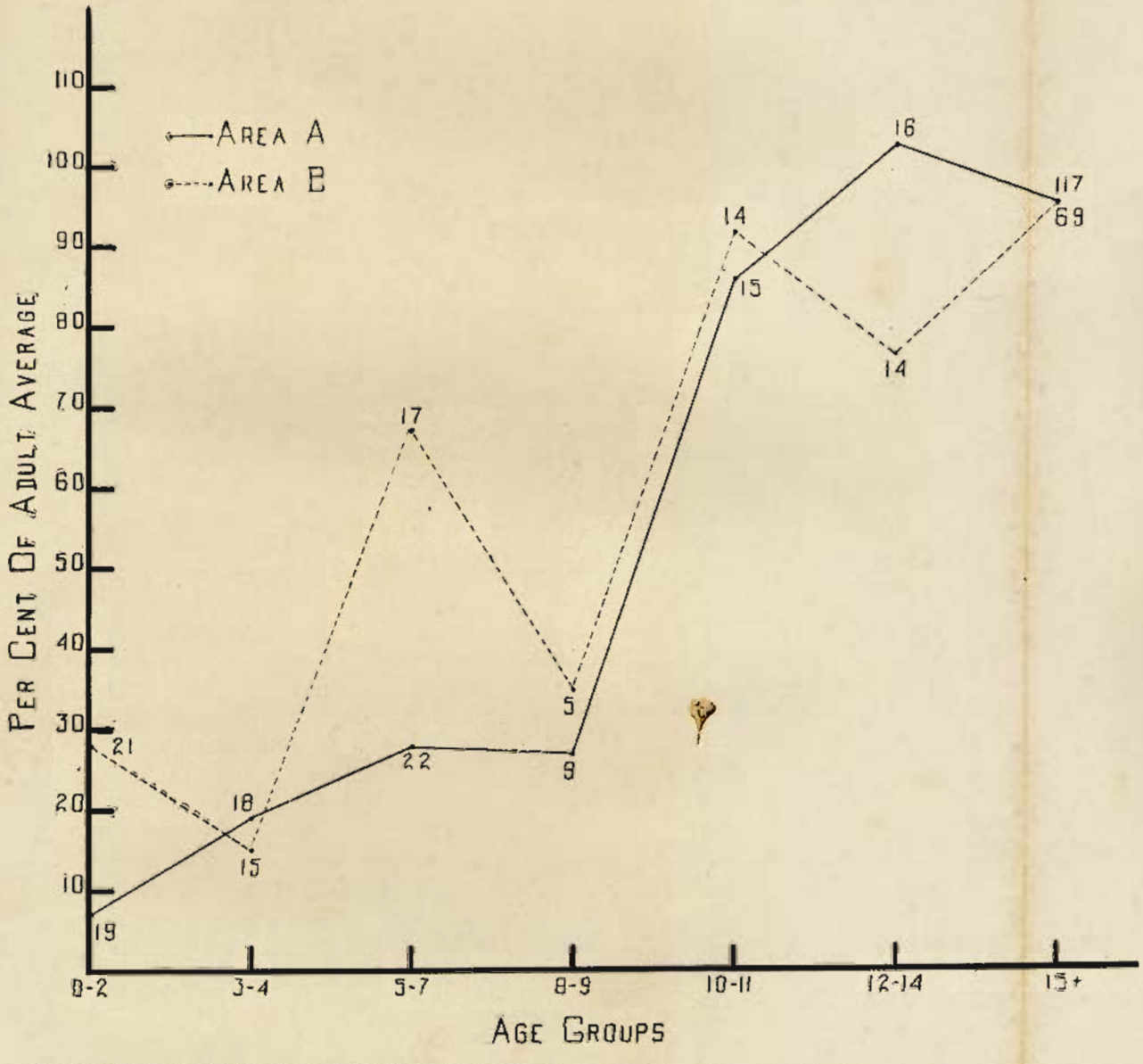
TABLE 1

EGG COUNTS OF AREAS A, B, AND C, ANALYZED ACCORDING TO AGE AND SEX

Age group	AREA A						AREA B						AREA C					
	Males		Females		Both Sexes		Males		Females		Both Sexes		Males		Females		Both Sexes	
	No.	Av. E.P.G.*	No.	Av. E.P.G.	No.	Av. E.P.G.	No.	Av. E.P.G.	No.	Av. E.P.G.	No.	Av. E.P.G.	No.	Av. E.P.G.	No.	Av. E.P.G.	No.	Av. E.P.G.
0–4	18	1,800	18	840	36	1,320	18	1,230	19	860	37	1,040	19	.....	18	10	37	5
5–9	13	5,400	9	1,130	22	3,690	15	3,230	17	1,990	32	2,570	30	350	21	200	51	200
10–14	16	9,210	12	1,180	28	5,670	18	13,270	13	7,660	31	10,920	15	450	15	1,090	30	770
15–39	27	11,010	21	2,060	48	7,090	45	12,640	44	7,130	89	9,920	33	1,180	69	1,060	102	1,100
40+	14	4,800	7	4,460	21	4,690	20	8,230	8	3,060	28	6,760	8	200	20	130	28	150
Total...	88	7,000	67	1,700	155	4,710	116	8,990	101	4,830	217	7,060	105	550	143	670	248	620
Corrected Average		7,490		2,040		5,120		8,780		4,810		7,050		610		620		610

* E.P.G.—eggs per gram as determined by the Stoll egg-counting method.



A representation of the rate of infection in the children examined from Finca La Sardinera, Areas A and B. The average egg count for each age group is given as a percentage of the adult average (15 years and over). The figures at each point in the curve represent the number of cases used in computing the value.