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The Effect of Snail Control on the Prevalence of *Schistosoma japonicum* Infection in the Philippines

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Snail control measures undertaken in Palo, Leyte, Philippines, in the course of a bilharziasis control project reduced the vector population by 95 % in two years. Stool examinations performed before and after the snail control operations indicate that the human prevalence of bilharziasis has shown a significant concomitant decrease in both the urban and coastal areas of Palo, that decrease being most pronounced in children under 10 years of age. No measurable reduction in prevalence occurred in the inland area of Palo, but snail control there appeared to protect the urban area downstream.

The authors discuss the manner in which data on the decline in the snail population can be used to predict the change in prevalence in each age-group examined.

The decline of snail populations during anti-bilharziasis work is usually accepted as presumptive evidence of success. It is agreed that complete elimination of the vector from a sufficiently large area would automatically constitute success. However, evidence of complete eradication of snails from a large area has not been presented to our knowlege, although the demonstration by Wright et al. (1958) in Egypt comes close to this degree of perfection.

Inasmuch as the relation between snail density and transmission has not been worked out with any accuracy, it follows that independent measurements of transmission must be made if claims of success are to be taken seriously. The universally used measurement consists in determining the prevalence of the disease at each age in samples of the population both before and after the snail control measures are carried out.

The present report covers human prevalence data from a base-line survey and a second survey taken after two years of successful snail control. The work was conducted by the Schistosomiasis Control Pilot Project at Palo, Leyte, Philippines. This project was started in July 1953 by the Philippine Government in collaboration with WHO and was assisted initially by a grant from the International Cooperation Administration. Detailed accounts of the preliminary research done in the course of this project have been published (Pesigan et al., 1958a, 1958b, 1958c). The publications referred to include a complete description of the area studied and of the methods developed for the control of the snail host.

At the beginning of 1957, the methods described in these earlier publications were put into effect in a large part of the municipality of Palo. The results of the work, in terms of the reduction of the snail population, are presented elsewhere in this issue.[3]

THE AREA

Palo is divisible into three parts on the basis of geographic and demographic features (Pesigan et al., 1958a). The urban centre of the municipality lies between two larger areas, the coastal and interior parts. *Oncomelania quadrasi*, the intermediate host of *Schistosoma japonicum*, occurs throughout the whole municipality, but is much commoner inland than elsewhere. When snail control was initiated, it was decided to concentrate on the urban and coastal areas because more people could be protected with less effort than would have been the case had the entire inland area been attacked. Only two of five inland zones were selected for snail control efforts. Although considerable snail reduction was achieved in these two zones, certain factors beyond the control

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of the project made the effort particularly difficult there, and no reduction in prevalence of the disease could be demonstrated among the small population inhabiting these two zones.

It is likely, however, that the snail control did serve to protect the larger population in the urban area. The two inland zones are directly upstream along the Palo River from the urban area, and the river had earlier been demonstrated to be a source of infection both in the town proper and between the two inland zones, in spite of the fact that the river itself harbours no snails. A similar situation was described by Sullivan & Ferguson (1946). Part of the continuing infection of the inland population must therefore have come from uncontrolled areas still further inland. Another part doubtless came from the main irrigation canal and its branches. This canal, which cuts across both inland zones, harbours a large population of snails, but was never placed under control for a variety of reasons, one of which was the difficulty of achieving co-ordination of effort with the irrigation authorities.

ANALYSIS OF THE DATA

Prior to snail control efforts, stool examinations were performed on age-stratified samples of the population. The data, pooled for urban and coastal areas, are given in Table 1. Data up to the 30th year of age only are included for reasons which will become obvious. This set of examinations was completed in 1954. At the beginning of 1957, snail control measures were instituted, and the results, based on an exhaustive sampling programme, showed that 50% of the snails in the area had been eliminated by July 1957 and 80% by July 1958. In July 1959, only 5% of the original population of snails remained.[1]

During the months July-October 1959, a second series of stool examinations was performed on the same population. The results of this survey are shown in Table 2. The gross percentage positive had apparently declined from 38.9 to 32.0. The difference between the two proportions is highly significant (χ^2 = is 15.76, with 1 degree of freedom). Inasmuch as a χ^2 value of 3.84 would indicate a significant difference between the surveys before and after snail control, the observed difference is very much greater than would be expected on a chance basis.

[1] See the article by N. G. Hairston & B. C. Santos on page 603 of this issue.

TABLE 1
AGE-PREVALENCE OF BILHARZIASIS IN PALO BEFORE SNAIL CONTROL OPERATIONS
(URBAN AND COASTAL AREAS COMBINED)

Age (years)	No. examined	No. positive	Fraction positive
Below 5	269	7	0.026
5-9	302	57	0.189
10-14	258	135	0.523
15-19	226	139	0.615
20-24	162	113	0.698
25-29	139	77	0.554
Total	1 356	528	0.389

It is necessary, however, to examine the data for bias through disproportional representation of different age-groups. It appears such a disproportion was operative in this case. The three younger age-groups were more heavily represented in 1959 than they were in 1954. When the proportional representation of each age-group in the two surveys is tested by χ^2, it is found that the 5-9-year-olds were significantly over-represented in 1959, and the age-groups 15-19 and 20-24 years were significantly under-represented in the same survey. Unfortunately, this bias is in the direction of the observed change in prevalence, and the simple comparison between the over-all percentages is therefore not a valid one.

TABLE 2
AGE-PREVALENCE OF BILHARZIASIS IN PALO TWO YEARS AFTER THE START OF SNAIL CONTROL
(URBAN AND COASTAL AREAS COMBINED)

Age (years)	No. examined	No. positive	Fraction positive
Below 5	352	2	0.006
5-9	432	53	0.123
10-14	354	163	0.460
15-19	191	129	0.675
20-24	134	82	0.612
25-29	158	90	0.570
Total	1 621	519	0.320

Indeed, had the same number of people been examined in each age-group in 1959 as in 1954, and had the observed infection rates for 1959 held exactly as observed, 36.0% of the total would have been positive. In this case, the value of χ^2 would have been 3.06, or less than enough to consider the difference significant.

The foregoing difficulty does not preclude valid comparisons between the two surveys if only one or two age-groups are compared at a time. Because of the small numbers positive in both surveys, comparison of the youngest age-group at the two times is pointless, but the 0-4-year-olds may be grouped with the 5-9-year-olds, and the prevalence rate for 1959 may then be compared with that for 1954. This is a valid comparison because the relative representations of the two age-groups are not different in the two surveys, and the data are therefore not biased as are the data for all ages under 30 years. The prevalence of bilharziasis among children less than 10 years old fell from 11.2% in 1954 to 7.0% in 1959. This difference is highly significant ($\chi^2 = 7.04$, with 1 degree of freedom).

A convincing demonstration that the observed decline in prevalence of the disease was due to the snail control measures requires evidence that the decline would not have taken place in the absence of snail control. This problem was anticipated, and parallel surveys were performed both in 1954 and in 1959 in the adjacent municipality of Tanauan. Tanauan appears to be sufficiently like Palo to serve as a comparison area. The results of the two surveys for the urban and coastal areas of Tanauan are shown in Table 3. The table includes data on children up to 10 years of age only, because this is the age-group in which the significant decline occurred in Palo. Between 1954 and 1959, the prevalence of bilharziasis showed a slight and non-significant rise in Tanauan, indicating that factors unrelated to the snail control activities had remained essentially stable during the interval. The conclusion seems justified that the snail control achieved a significant reduction in the prevalence of bilharziasis, especially among young children.

TABLE 3

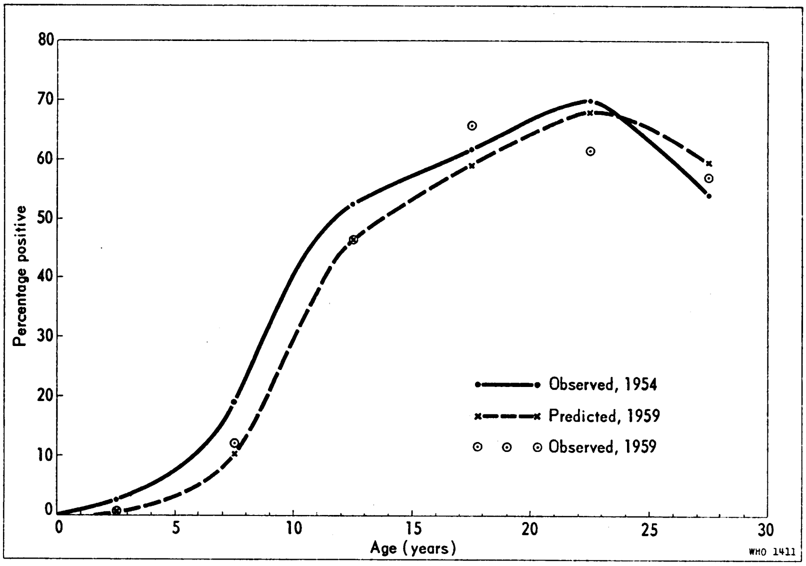
PREVALENCE OF BILHARZIASIS IN CHILDREN LESS THAN 10 YEARS OLD IN TANAUAN, THE COMPARISON AREA FOR PALO

Year	No. examined	No. positive	Fraction positive
1954	239	26	0.109
1959	332	46	0.139

SYNTHESIS OF DATA ON SNAIL POPULATIONS AND HUMAN PREVALENCE

The interested administrator may wish to know more than whether the reduction in prevalence was statistically significant. He may wish to know whether the observed reduction is as much as could have been expected from the success of snail control measures and from the length of time over which such measures have been effective. The question cannot be answered with the assurance provided by a statistical test, but an approach to the answer can be made if certain reasonable assumptions are permitted. The first such assumption is that for short periods of time the mortality of adult flukes is too slight to have much effect upon prevalence in younger age-groups. Support for this assumption can be found in the original epidemiological study in Palo, where it was found that less than 8% of known stool-positive individuals became negative after approximately one year. Most of these people were over 25 years old (Pesigan et al., 1958a). This means that in order to obtain an idea of how much reduction to expect, it is only necessary to move the age-prevalence curve to the right by as much time as snail control has been effective. In the present case, the snail population data indicate that transmission of the parasites must have been greatly reduced for about 1½ years before the 1959 survey. The maximum reduction in prevalence to be expected at that time may therefore be obtained by the following procedure: first, plot the observed points for the 1954 survey on a graph of prevalence against age; secondly, draw as smooth a curve as possible through these points; thirdly, estimate the new expected percentage positive for each age-group by changing the percentage positive until the point lies 1½ years to the right of the original age prevalence curve. This has been done in the accompanying figure. It is observed that the greatest reduction in prevalence is expected to occur in the younger age-groups, people older than 15 years being expected to show little change because most of them were already infected before transmission was interrupted.

COMPARISON OF AGE-PREVALENCE CURVE FOR 1954 WITH OBSERVED AND PREDICTED DATA FOR 1959 (URBAN AND COASTAL AREAS OF PALO COMBINED)



The actual observations for 1959 have also been indicated on the figure. The closeness with which they match the expected curve, especially in the younger age-groups, indicates that the reduction in prevalence is as great as could reasonably have been anticipated.

RÉSUMÉ

Les mesures prises dès 1958, à Palo, Leyte, Philippines, pour lutter contre *Oncomelania quadrasi*, vecteur de *Schistosoma japonicum*, ont eu pour conséquence de réduire de 95 % en deux ans la population des mollusques. Des examens de fèces, avant et après les opérations, indiquent une baisse significative de la fréquence de la bilharziose dans les districts urbains et côtiers de Palo. Cette baisse est particulièrement nette chez les enfants de moins de 15 ans, et ne s'observe pas dans le groupe d'âge de 15-30 ans. Dans la commune voisine, Tanauan, où aucune mesure de lutte n'avait été appliquée, on ne constata aucune baisse de la fréquence globale. Les résultats, que les auteurs exposent et discutent, semblent justifier la conclusion selon laquelle la transmission de la maladie, des mollusques à l'homme, a été interrompue par les mesures de lutte contre les vecteurs.

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