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STUDIES ON *SCHISTOSOMA JAPONICUM* INFECTION IN THE PHILIPPINES *

1. General Considerations and Epidemiology

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SYNOPSIS

The geographical location and physical features of the island of Leyte in the Philippines, where bilharziasis is endemic and where the studies reported here were conducted, are described in the first part of this paper. An account is also given of the climate, soils, vegetation, population and rural structure, and public health of the island.

The second part opens with a brief historical review of bilharziasis japonica in the Philippines up to 1953, when a control project was started. The objectives of this project, the areas selected, the census data and sampling used, and the techniques adopted are described. There follows a discussion of the prevalence of bilharziasis and its relationship to age, sex, occupation and environment; the prevalence of other common helminthic infections is also considered. In a section on the natural history and public health significance of bilharziasis, an approach to quantitative assessment of disease and disability and a method for evaluating the economic burden of bilharziasis are suggested. The incidence of disease in children of 5-9 years is reviewed in the same section. An analysis is made of possible strain differences of *S. japonicum* in Leyte, and the relative role of human and other animal hosts is assessed. The last section deals with the egg-laying habits of *S. japonicum*.

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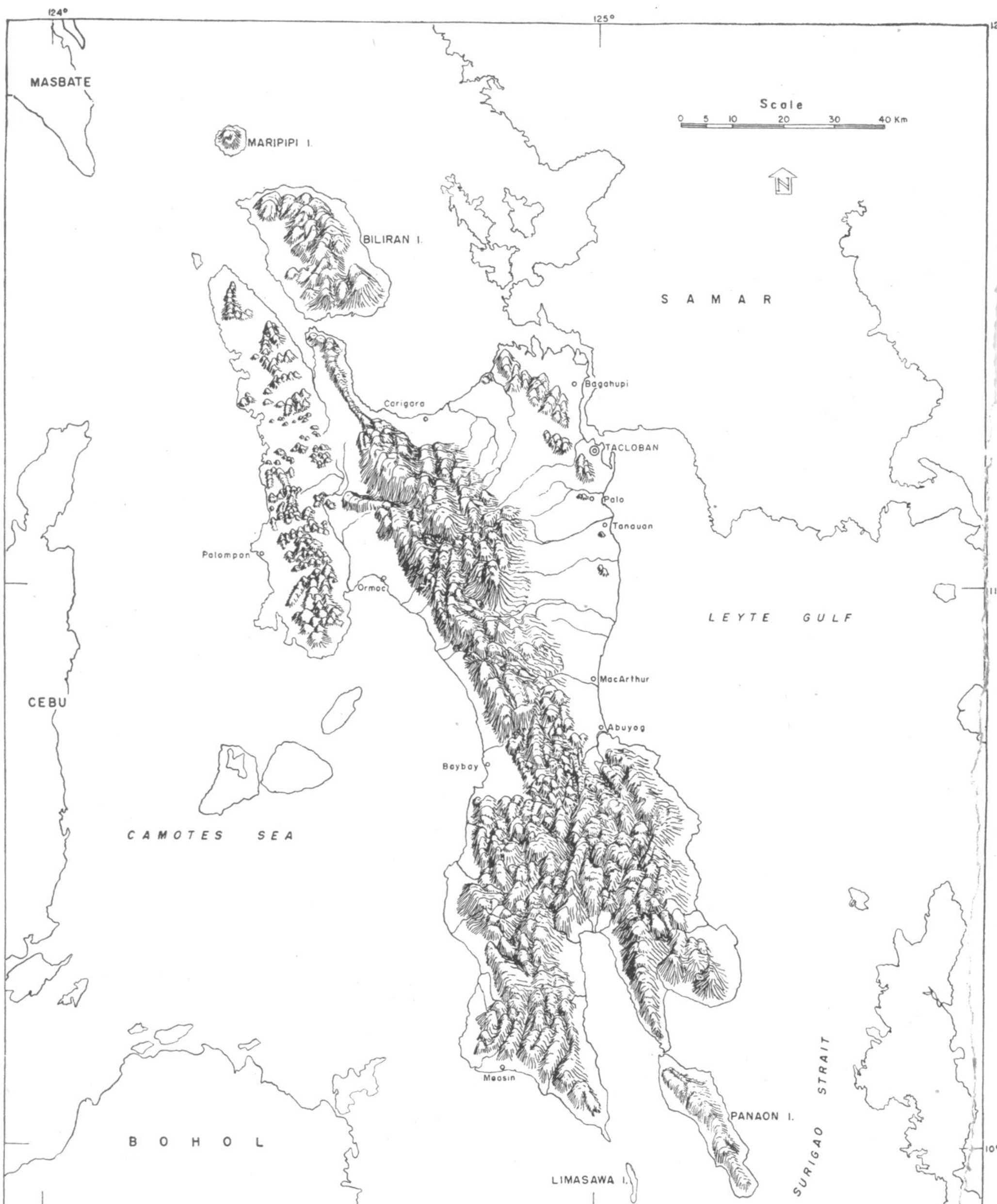
FIG. 1. RELIEF MAP OF LEYTE PROVINCE, PHILIPPINES



GENERAL CONDITIONS

Geographical Location and Physical Features

The two large islands of the Philippines, Luzon in the north and Mindanao in the south, are separated by a group of smaller islands, the Visayan group, of which Leyte is the strategic key and centre. This central group is pierced by two navigable straits, the northern strait of San Bernardino, and the southern strait of Surigao leading directly to Leyte.

Leyte Province is composed of the mainland and several small islands of which the important ones are Biliran and Maripipi in the north and Panaon and Limasawa in the south.

The general relief of the province is shown in Fig. 1 (adapted from Barrera & associates, 1954).

The mainland of Leyte province—the island of Leyte proper—is long, measuring 214 km diagonally from the north-western tip to the south-eastern end, and is 72 km across the widest portion (between Tacloban and Palompon), while the narrowest part is 25 km (between Abuyog and Baybay). The island has a total area of approximately 7200 km^2, and is generally mountainous with nearly 75% rough mountain and rolling uplands and 25% flat lowlands.

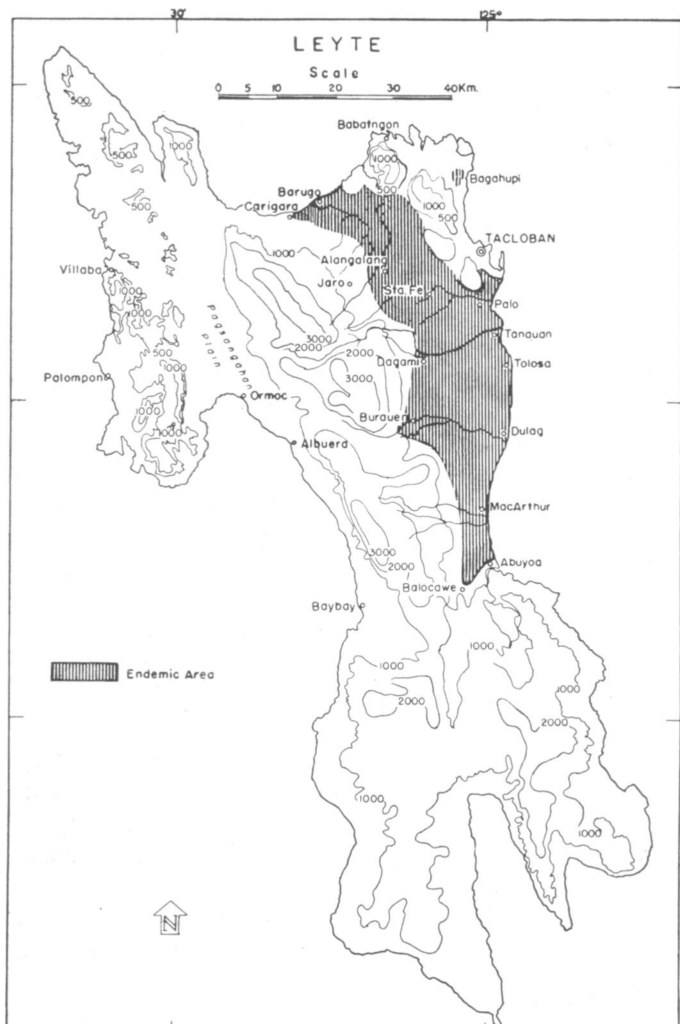
A range of mountains, the central cordillera of Leyte, following the general direction of mountain ranges in the Philippines, runs north and south, closer to the west than to the east coast.

The area from Palo south to Abuyog (52 km) and from Palo north to Carigara (40 km) is a long stretch of plain, shown in Fig. 2. This plain is bounded on the east by another mountain range and has a width that varies from 11 km to 20 km across, converting part of the plain into a valley. This plain and valley, with outcrops of low isolated hills, form one continuous stretch of flat lowland. It is nearly 1200 km^2, constituting approximately one-sixth of the total area of the island of Leyte. This is the most important part of Leyte in our present study, as it is the endemic area for bilharziasis in the province.

Across this endemic area run numerous perennial rivers, deep enough for light boats to navigate as far as 10 km or more inland, depending upon the tide. They often swell and cause floods during the period of heavy rains (November-January). At places, the rivers run parallel to the coastline and within almost 1 km of it. It is suspected that these may formerly have been lagoons. In many places wide depressions exist into which the water drains, causing swamps to develop.

A study of aerial photographs shows that numerous depressions parallel to the coast are a characteristic feature of the topography of eastern Leyte. It is believed that these depressions were produced by some type of marine activity. Another characteristic of this plain is the existence of low isolated hills along its eastern flank, as in Palo, Tanauan, Tolosa, Dulag and Abuyog. Such a topography results naturally in very poor

FIG. 2. AREA OF ENDEMIC BILHARZIASIS IN LEYTE PROVINCE



drainage with a very shallow water-table. Conditions have been stated to have become worse as a result of the various military operations in this area during the Second World War. The armies, occupying principally the areas along the shores, bulldozed, dammed, and blocked the natural drainage ways of the interior fields at a number of places (Barrera and co-authors, 1954).

In contrast to this, the western coastline of Leyte is generally well elevated and slopes rather steeply to the sea. There is no space for vast swampy areas, as on the eastern side, except in the valley between the western range of hills and the northern part of the central cordillera, known as the Pagsangahan plain. There are no vector snails in western Leyte and therefore there is no bilharziasis in the area.

Climate

The Province of Leyte lies approximately between 10° and 12° N, which is within the tropical rain forest type of world climate, being warm and humid, and characterized by abundant rainfall throughout the year and by the presence of rank vegetation.

Although local winds may be variable, frequently reversing their direction at Tacloban in the course of a single day, the prevailing winds conform to a definite pattern. From February to April, winds are mostly easterly and south-easterly; in May, the south-west winds (frequently called the south-west monsoons) begin to blow, lasting through September. From October to January, the north-east trade winds predominate.

Rainfall

Due to the presence of the central cordillera in Leyte, the climate on the eastern side of the range is somewhat different from that on the west. The eastern side is exposed to the north-east trade winds which are responsible for the distribution of its rainfall. There is no dry season and a pronounced rainy period occurs from November to February. The trade winds, upon passing across the central mountain range, are deflected to a certain extent so that there is less rain on the western side, which has been classified by the Weather Bureau as having no pronounced wet or dry seasons. An examination of the details of rainfall at Ormoc, however, shows that there is almost as much average difference between the wettest and driest months as there is at Tacloban. The months of heavier rains do not coincide in the two places, being from November to January in Tacloban and from July to November in Ormoc. The west coast is thus clearly more influenced by the south-west wind.

To sum up, there is no dry season in Leyte and rains are heavier during winter months in eastern Leyte. An average annual rainfall of 252.4 cm occurs in eastern Leyte and 228.2 cm in western Leyte. Rain distribution as recorded at Tacloban on the east and Ormoc on the west coast is shown in Table I and Fig. 3.

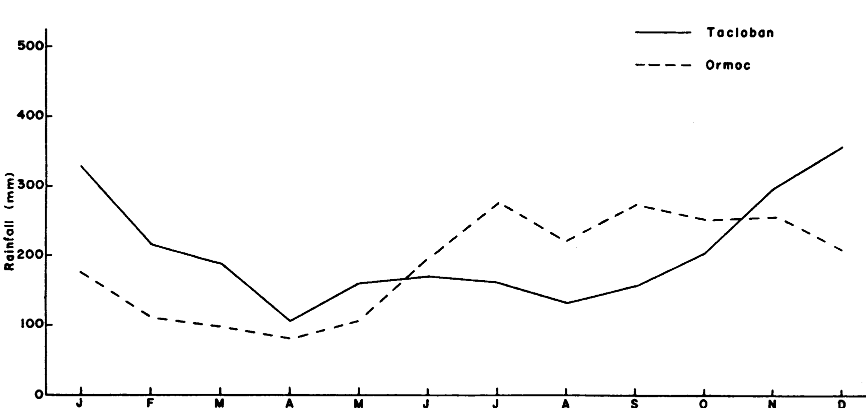
TABLE I. AVERAGE MONTHLY RAINFALL AND NUMBER OF RAINY DAYS IN EAST LEYTE (TACLOBAN CITY) AND WEST LEYTE (ORMOC CITY)*

Month	Tacloban City (43 years' average)		Ormoc City (38 years' average)	
	rainfall (cm)	rainy days	rainfall (cm)	rainy days
January	33.0	22	17.6	16
February	21.6	17	11.4	12
March	18.5	18	9.9	13
April	13.1	15	8.1	11
May	16.2	16	10.9	12
June	17.2	17	19.6	16
July	16.3	17	27.8	19
August	13.4	15	22.5	17
September	15.7	16	27.7	19
October	20.8	20	25.6	21
November	30.2	21	25.9	19
December	36.4	23	21.2	19
Annual	252.4	217	228.2	194

* Source: Weather Bureau records, Philippines.

Days completely devoid of sunshine are relatively rare in eastern Leyte; on the other hand, at least half the days in the driest months (April and August) are officially classed as " rainy ", meaning that at least 0.25 mm of rain has fallen. December (the wettest month) has an average of 23

FIG. 3. AVERAGE MONTHLY RAINFALL IN LEYTE



rainy days, and the annual average is 217 rainy days. Ormoc, as might be expected, has fewer rainy days than Tacloban, averaging 194 a year.

Temperature

While the amount of rainfall in the east differs from that in the west, differences in temperature in these two places are insignificant. The mean maximum temperature at Tacloban is 31.11°C (88°F) while the minimum is 24.1°C (75.4°F), a difference of 7.01°C (12.6°F). Comparable figures for Ormoc are 31.44°C (88.6°F) maximum, and 22.3°C (72.2°F) minimum, a difference of 8°C (16.4°F). Table II and Fig. 4 show the small average monthly variations.

TABLE II. AVERAGE MONTHLY MAXIMUM, MINIMUM AND MEAN TEMPERATURES (°C) IN EAST LEYTE (TACLOBAN CITY) AND WEST LEYTE (ORMOC CITY) *

Month	Tacloban City			Ormoc City		
	mean (42 years)	mean max. (14 years)	mean min. (14 years)	mean (16 years)	mean max. (10 years)	mean min. (10 years)
January	25.6	29.33	23.11	25.22	30.77	21.77
February	25.83	29.93	23.11	25.22	30.77	20.72
March	26.33	30.55	23.55	25.77	31.61	21.22
April	27.33	31.77	23.88	26.38	33.33	21.88
May	27.77	32.0	24.77	26.77	32.11	22.77
June	27.55	31.94	24.83	26.72	31.72	32.00
July	27.33	31.83	24.5	26.72	31.38	23.38
August	27.66	32.33	24.72	26.77	31.61	23.38
September	27.44	32.0	24.5	26.61	31.27	22.88
October	27.0	31.55	24.33	26.11	31.38	22.61
November	26.45	30.55	24.0	25.77	31.38	22.38
December	25.94	29.66	23.61	25.72	31.00	22.11
Annual	26.83	31.11	24.11	26.16	31.44	22.33

* Source: Weather Bureau records, Philippines.

Humidity

Relative humidity is high in Leyte, though lower in the west than in the east (Table III and Fig. 5), as would be expected from the difference in rainfall. Leyte lies south of the belt of heavy and frequent typhoons.

FIG. 4. AVERAGE MONTHLY TEMPERATURE IN LEYTE

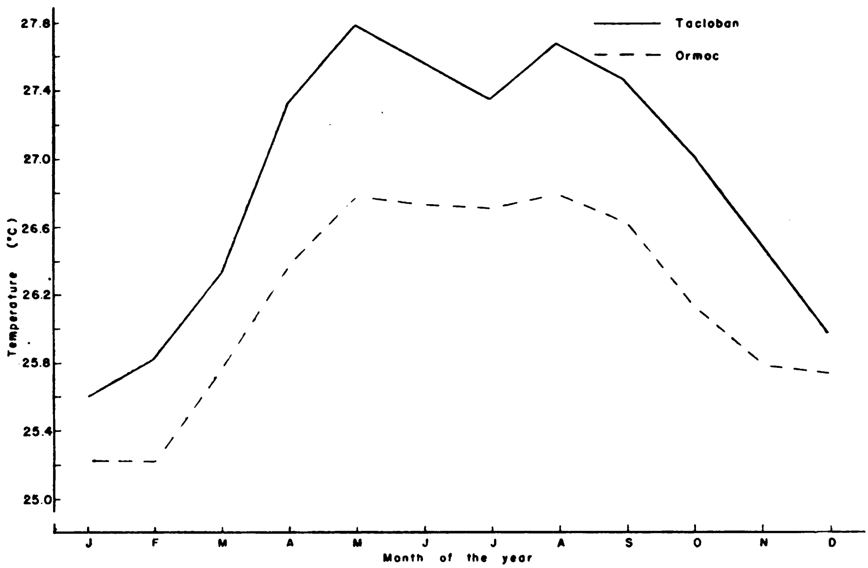
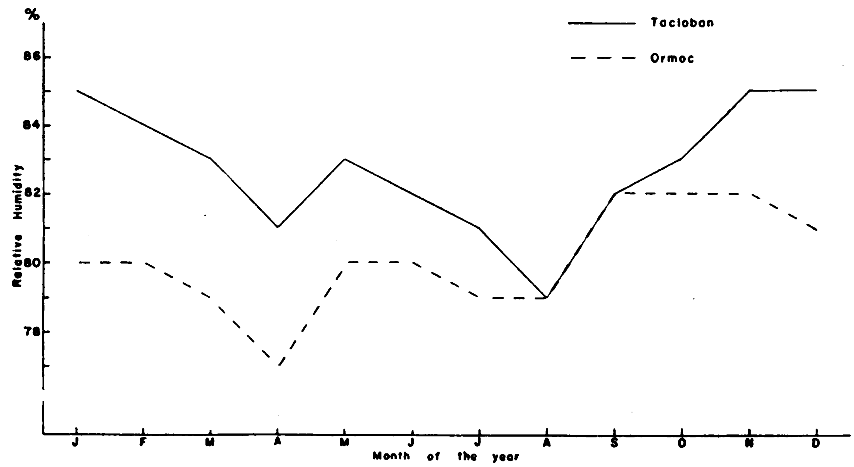


TABLE III. MEAN RELATIVE HUMIDITY (%) IN EAST LEYTE (TACLOBAN CITY) AND WEST LEYTE (ORMOC CITY) *

Month	Tacloban City (15 years' average)	Ormoc City (5 years' average)
January	85	80
February	84	80
March	83	79
April	81	77
May	83	80
June	82	80
July	81	79
August	79	79
September	82	82
October	83	82
November	85	82
December	85	81
Annual	83	80

* Source: Weather Bureau records, Philippines.

FIG. 5. MONTHLY RELATIVE HUMIDITY IN LEYTE



Soils of Leyte

The three most important soil series of Leyte are named the San Manuel, the Palo and the Guimbalaon (Barrera and co-authors, 1954).

The San Manuel series, of the moderately drained flat lowland, is developed from alluvial deposits and has a profile of several layers of loose, friable, structureless and deep soils. It has a higher proportion of sand than of silt or clay and is fairly rich in organic matter. The water-table is fairly deep, 2-4 m from the surface. It is extensively cultivated for rice, coconuts, bananas, sweet potatoes, peanuts and vegetables. Bamboo groves are seen along the banks of creeks and rivers in this soil.

The Palo series, of the poorly drained flat lowland, is developed from recent alluvial deposits. No stones or rocks of any size are found either on the surface or in the substratum. It has about equal amounts of sand, silt and clay. The surface soil is brown clay loam of a fine granular structure. This top layer is fairly rich in organic matter supplied by dead grasses and rice straw. The soil seldom cakes or hardens from drying. If properly drained, it is considered the best soil for agriculture in the province. The water-table is usually about 1 m from the surface. Lowland rice, coconut, corn, cassava and sweet potatoes are the most common crops cultivated.

The Guimbalaon series, of the well drained rolling uplands, is developed from old volcanic deposits. It has a distinct dark brown colour and a good granular structure. Occasional rock outcrops are found. It has a higher proportion of clay than of sand or silt, and is sticky and becomes hard when dry. It has a fair amount of organic matter and is acid in reaction. It is mostly used for coconuts, sugar-cane and corn, rarely for rice. The topography is rolling to roughly rolling.

The predominant series of soil in the endemic eastern plain and in the valley is of the Palo clay loam type, with a mosaic of other types intervening, except in the lower quarter of the plain, which is partly San Manuel silt loam and partly Palo clay loam.

Vegetation

The central range of hills is well covered by virgin forest, and good lumber of commercial value is found (Fig. 6). The primary forest has a thick upper canopy and only a scanty amount of sunlight can penetrate. The undergrowth consists of vines, ferns and palms. Trees at higher altitudes are covered with mosses, ferns and other plants. The hills on the north-western part are mostly grasslands used for pasture. Most of the southern part of Leyte has also become grassland as a result of the "shifting" agriculture known as " Caingin cultivation "; new patches of forest are cleared and old ones abandoned, and grasses and bush soon cover the uncultivated clearings.

In the low depressed areas in the plain and valley of eastern Leyte fresh-water swamps are numerous, with the water staying in them throughout the year. In these swamps plants like palawan (*Cyrtosperma merkussii* (Hassk) Shott, family Araceae), puropasagui (bicel) (*Frimbistylis globulosa* (Retz) Kunth, family Cyperaceae), badiang (*Alocasia macrorrhiza* (Linn.) Shott, family Araceae), lumbia (*Metroxylon sagu* Rottb., family Palmae), and water hyacinth (*Eichornia crassipes* (Mart.) Slms, family Pontederiaceae) grow in abundance (Brown, 1951; Barrera and co-authors, 1954).

Mangrove nipa palm (*Nypa fructicans* Warmle, family Palmae) are found in many areas near shores and mouths of rivers.

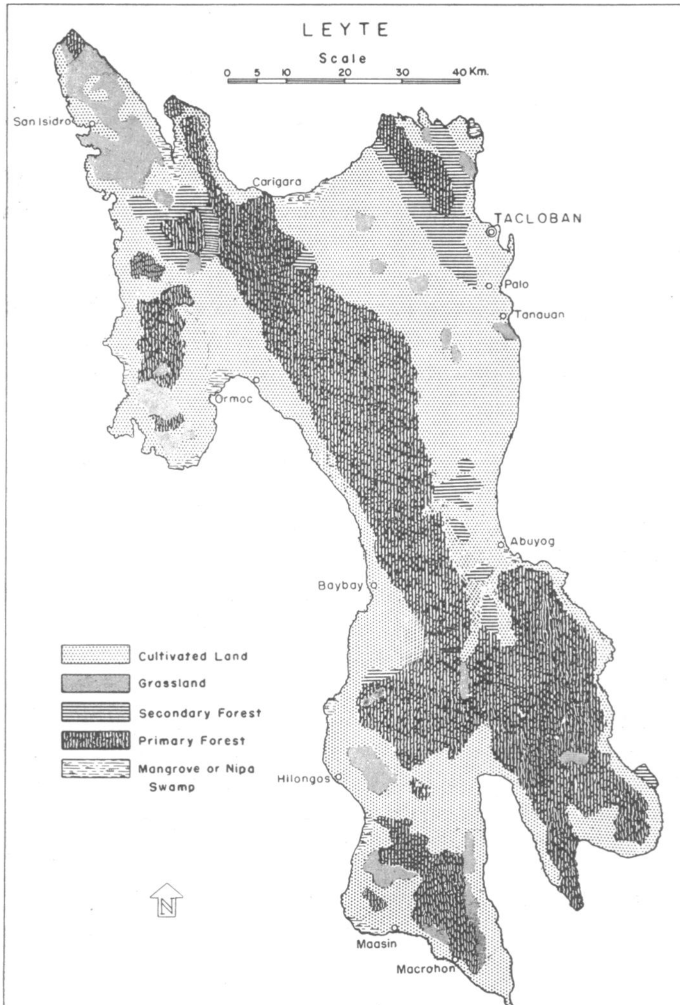
Many kinds of tall grasses—mostly cogon (*Imperata cylindrica* (Linn.) Beauv., family Gramineae)— shrubs of various kinds, ferns and vines grow luxuriantly everywhere, making the countryside look lush and green all the year round.

Population and Rural Structure

The population growth of Leyte during the past half-century has been rapid and continuous—from 338 922 in 1903 to 597 950 in 1918 and to 1 006 891 in 1948. Precise comparison of the rates of increase between the successive censuses is hardly valid but the over-all indication is a rate of increase that approximates 2% per year, which is about the average for the rest of the Philippines through the first half of this century.

The density of population is nearly 125 per km^2 (325 per square mile) in Leyte, which ranks among the more densely populated provinces of the Philippines, the average density for all provinces being 71 per km^2

FIG. 6. VEGETATION MAP OF LEYTE PROVINCE *



* Adapted from Barrera, Aristorenas & Tingzon (1954)

(185 per square mile). The population pressure on land, better expressed as the population per unit area of cultivated land, is approximately five persons per hectare. An adequate land-man ratio has been reckoned by the Philippines Committee on Social Amelioration at two persons per hectare.

The province is divided into 60 municipalities or towns. The central part of the municipality, with its municipal offices, church, plaza, market place, school, and health centre, form the " población ". Some 20% of the total population live in such centres and could be regarded as urban to semi-urban in character. The remaining 80% of the population live in small rural communities, called " barrios " (villages), which average 10-20 in each municipality and constitute the primary social group. A barrio is the smallest recognized unit, with sometimes smaller neighbourhood units known as " sitios " or " puroks ".

The two chartered cities, Tacloban, the capital of the province on the east coast, and Ormoc, on the west coast, have a total population of 40 000, which could be regarded as wholly " urban ".

The total number of barrios in the province is 930; these radiate some 5-15 km from the población and are not connected to it by good roads. During heavy rains, the rivers may cut off the trails, and the barrios may remain isolated for varying lengths of time.

Public Health

Personnel

It has been stated that few countries in the Far East equal the Philippines in their efforts towards advancement of personal and public health (Simmons et al., 1944; Balfour et al., 1950). Perhaps with the exception of Japan, no other country in the Far East makes so great an annual budgetary provision for health; for 1956-57 this amounted to 2.00 pesos (US$1.00) per caput. Leyte enjoys the benefits of this with the rest of the country. The total health budget, inclusive of medical care, for the province is 600 000 pesos annually; this works out at 60 centavos per caput. Municipalities are required to earmark at least 5% of their income for public health. The rest of the expenses on rural health are met from provincial and national funds.

Control of the major epidemic diseases has been notable: plague occurred last in 1914; smallpox has been absent since 1920; and cholera was brought under control in 1932.

There are 80 physicians in active practice in Leyte, of whom 60 are employed by the Government. The general ratio is one physician to 12 500 inhabitants and the usual urban concentration exists. There are 90 sanitary inspectors, who are a recognized part of the staff in the rural health units but are generally poorly trained. Nurses, including 26 public health nurses, number 81, of whom 60 are in the Government service. There are 31 dentists in the province, including 14 in the Government's employ. The province has a total hospital bed capacity of 316, approximately one bed per 3000 persons. Except for the 30 beds in a half-empty maternity home in Palo, the rest of the hospital beds (286) are in the three large urban centres of Tacloban, Baybay and Ormoc. There is therefore no in-patient accommodation available in the rural areas of Leyte.

Rural health service

Up to the time of the passing of the Rural Health Act (Republic Act 1082) in 1954, the local health and medical services in the rural areas were received from three separate entities, the President, Sanitary Division (as the local health officer was called), municipal maternity and charity clinics, and the puericulture centres. These activities were mostly limited to the población (the central area of a municipality), and the barrios received almost no benefit. Many municipalities were without health or medical care and in areas where personnel and facilities were available, it was frequently overlapping or duplicated. Some special programmes were carried out without particular co-ordination or integration at the local level (ICA, 1955).

The new Act has created the position of provincial health officer in the province and the position of municipal health officer for each municipality, with preventive and out-patient care under one health unit. Each unit consists of a physician, public health nurse, midwife and sanitary inspector; larger municipalities (over 35 000 population) will be strengthened by additional staff, and from 1956, 39 health units with full complement of staff were in operation in this province. Complete coverage is envisaged by July 1958. How far these units will meet the barrio needs depends on the efficiency and enthusiasm of the staff employed. However, at present, it is disconcerting to note that, according to the 1954 annual report of the Leyte Provincial Health Officer, 95.5% of deaths in Leyte occur unattended by any physician. Attendance at the rural health centres, which provide mainly a diagnostic service and a prescription to the patients to be purchased at a pharmacy, is small considering the population served. Plans are being implemented to make the municipal health officer hold his clinics at suitable centres in the barrios by rotation every week.

Practically every barrio has " herbolarios " (quack-doctors) and " hilots " (untrained midwives). The barrio people have faith in their healing capabilities. The herbolarios mostly use herbs and sometimes the much advertised patent medicines and even placate evil influences, which are locally believed to be the main cause of illnesses. We believe that it is neither reasonable to expect ready acceptance of scientific ideas that conflict with deep-seated beliefs and practices, nor advisable to impose changes in total disregard of the local traditional attitudes.

Statistics

Vital statistical data are of very limited value because of their incompleteness and inaccuracy. The manner of collecting the basic data at their local source, the lack of physicians in many rural areas, the method of having the cause of death established by a sanitary inspector or other person according to the statement made by the notifying member of the family, are among the important factors that contribute to their unreliability.

The principal health indices for Leyte province (with national rates in parentheses) for 1954, taken from the Provincial Health Officer's report and the International Co-operation Administration health report (1955), are:

Crude birth-rate	30.96 (33.17) per 1000 population
Crude death-rate	12.10 (10.28) per 1000 population
Infant mortality rate	95.51 (94.18) per 1000 live-births

TABLE IV. REPORTED DEATHS BY CAUSES IN LEYTE PROVINCE (1953-54) * WITH CORRESPONDING NATIONAL DEATH-RATES IN PARENTHESES **

Causes	Number of deaths in 1954	Death-rate per 100 000 population
1. Tuberculosis	1300	136.54 (110.91)
2. Acute bronchitis	1228	128.98 (90.61)
3. Broncho-pneumonia	996	104.61 (94.54)
4. Beriberi, adult	902	94.74 (3.45)
5. Beriberi, infant	737	77.41 (77.59)
6. Congenital debility	494	51.89 —
7. Pneumonia (lobar, lobular, bronchial)	465	48.84 (30.98)
8. Influenza	306	32.14 (24.72)
9. Diarrhoea & enteritis (under 2 years)	190	19.96 (44.28)
10. Simple meningitis	110	11.55 —
11. Diarrhoea & enteritis (over 2 years)	98	10.29 (21.28)
12. Whooping cough	57	5.99 (2.56)
13. Tetanus	36	3.78 (7.99)
14. Rabies	27	2.84 (0.98)
15. Measles	23	2.43 (2.67)
16. Malaria	15	1.58 (24.72)
17. Typhoid fever	13	1.37 (0.89)
18. Dysentery (bacillary)	10	1.05 (0.56)
19. Food poisoning	10	1.05 —
20. Dysentery (amoebic)	3	0.32 (1.44)
21. Diphtheria	1	0.11 (1.0)

* Source: Annual report of the Provincial Health Officer, Leyte (1954).
** Source: Annual report of the International Co-operation Administration (1955).

That these rates must be used with great caution is shown by the fact that the municipal returns on which they are based show very great variations, for both natality and mortality, with no apparent cause recorded in explanation.

Table IV shows deaths by causes as reported by the Provincial Health Officer for the fiscal year 1953-54 (July-June) for Leyte. The five leading causes of death, as listed are: pulmonary tuberculosis, bronchitis, bronchopneumonia, beriberi (adult and infant). Diarrhoea and enteritis also rank high among the important causes. The corresponding figures in parentheses are national figures for the Philippines for the same period. While these figures may provide some index of health in Leyte, they are affected very much by under-reporting and lack of proper diagnosis. We are therefore not surprised that bilharziasis is not even listed among the causes of death in the province.

Of the estimated one million inhabitants in the bilharziasis endemic areas delineated in the 12 infected provinces of the Philippines, over one-third (390 000) live in the 404 barrios of the 20 municipalities in the endemic plain and valley of eastern Leyte. It is our conservative estimate that at least one-third of them or a total of 130 000 persons in the area are infected. The team of consultants on bilharziasis sent by WHO to the Philippines in 1952 were of the opinion that the disease represents a very serious problem and that in Leyte it contributes to the downward economic trend. Pesigan (1953) considered the prognosis of the disease in general to be poor and estimated that a

> " 15-year old patient with moderate infection may live from 5 to 10 years if he remains in an endemic area, but his life becomes miserable and his capacity for work is reduced until he gets bedridden and dies. Others with a single and light infection survive with early treatments ".

We shall discuss the public health significance of bilharziasis in this area fully in another section of this report.

Intestinal parasitism has been described as the most common disease condition met in the Philippines, and it is undoubtedly true of Leyte, as shown by the surveys conducted in 1949-50 (Pesigan, 1950). The prevalence rates, based on 14 061 persons examined in 10 towns in eastern Leyte, were: *Ascaris* 88.5 %; *Trichuris* 55.9 %; *Ancylostoma* 38.7 %. The combined rate for one or more of these three parasites was 99.6 %. Table V gives details for the different towns examined in the area.

Pointed attention has been drawn to the public health importance of these infections in the Philippines by both the early workers (Tubangui, 1948) and the present-day workers (Lara et al., 1953). The WHO consultant team on bilharziasis, referring to the relationship of bilharziasis to intestinal helminthiasis, observed that as an over-all health problem instestinal helminths are probably more important than bilharziasis but that familiarity

TABLE V. PREVALENCE OF INTESTINAL HELMINTHS IN EASTERN LEYTE IN 1949-50 *

Municipalities	Number of persons examined	Number positive for parasites	Percentage of parasitism	Prevalence of parasitism					
				Ascaris		*Trichuris*		*Ancylostoma*	
				number	%	number	%	number	%
Total for Leyte	14 061	14 002	99.6	12 448	88.5	7 863	55.9	5 446	38.7
Burauen	2 518	2 510	99.7	2 115	84.0	1 376	54.7	1 195	47.5
Dagami	2 147	2 139	99.6	1 885	87.8	1 053	49.0	983	45.8
Tanauan	2 200	2 178	99.0	2 025	92.0	1 510	68.6	895	40.7
Palo	2 034	2 018	99.2	1 755	86.3	1 330	65.4	496	24.4
Santa Fe	512	510	99.6	450	87.9	374	73.0	181	35.4
Pastrana	416	416	100.0	396	95.2	265	63.7	144	34.6
Dulag	2 031	2 030	99.9	1 873	92.2	783	38.6	646	31.8
Tolosa	108	108	100.0	99	91.7	40	37.0	43	39.8
Abuyog	1 516	1 514	99.9	1 328	87.6	812	53.6	684	45.1
MacArthur	579	579	100.0	522	90.2	320	55.3	179	30.9

* Source: Pesigan (1950).

has made it easy to ignore them. This subject will be reviewed in greater detail later in this report.

Housing

Housing is extremely simple, highly functional, well ventilated and fairly economical in the barrios. Nearly all dwellings are constructed of accessible local materials. The typical rural dwelling has roof of nipa palm or cogon grass, woven split bamboo siding, door and window, and a bamboo floor. The structural framework is constructed of bamboo poles or other local wood. Houses are set on stilts about 1-2 m high to avoid floods and high water. This ground space is often used as pig-pen or a store-place for lumber and junk of all kinds.

The typical three-roomed house has a living room, kitchen and sleeping room. Items of household equipment are few and simple—a wooden chest or two, hammock and bamboo bench. Houses of the better type have galvanized iron roofs and wooden floors, which are marks of housing distinction. Most of the houses are along roads or in clusters at the edge of rice-fields.

Sanitation and personal hygiene

Sanitation in Leyte on a community or environmental basis is poor and is made worse by heavy rains and the thick growth of vegetation of all kinds around dwellings and the rotting of fallen banana trees and decaying vegetation. Pigs wallow in waste water under the houses. There is no system of drainage anywhere; the concrete surface drains which exist in larger towns become stagnant cesspools and breed mosquitos. Flies are not as abundant as in the drier tropics, but ants and cockroaches abound and so do rats.

Approximately 12% of the total population have latrines of some kind and the rest of the barrio people seek concealment behind bushes for defaecation and do not use water for ablution. They generally squat on a fallen coconut tree or banana stump or any other object to keep their feet off the ground while defaecating. " Pig latrines " are a common feature in Leyte, where the pigs act as ready scavengers. The men make no effort to urinate in privacy.

Approximately 22% of the population in Leyte have protected water supplies (piped water or artesian wells); 55% have semi-protected water supplies from sanitary dug-wells or improved springs; and the remaining 23% have water from unprotected sources. This position cannot be considered wholly unsatisfactory. Very rarely is surface water from rivers and ponds used for purposes other than washing clothes. Wells are not the social meeting-place for women as is the case in large areas of South-East Asia. No labour is involved in drawing water from shallow wells with a high water-table; the usual method is to use a small can attached to the end of a stick 3-4 m long.

Personal hygiene is remarkably good. The Leyteños, in common with the Filipinos in general, are one of the cleanest and most neatly dressed people in the East, changing, washing and ironing their clothes with great frequency, even though living in the remotest barrios under unhygienic conditions. In the barrios wooden clogs are often worn by women, while men and children wear nothing on their feet except on social occasions.

Nutrition

Rice, sweet potatoes, cassava, gabi (taro), bananas, fish, vegetables, some meat, and vinegar constitute the basic diet. The food is mostly unvaried and monotonous. Rice and fish are the chief support of the population, and constant recourse to importation of these two basic commodities shows insufficient productivity. Vegetables and spicy sauces are important adjuncts to the dietary pattern and sugar is much used. Vinegar seems an unusual item to list in the basic dietary but it plays a most important role in food preparation, flavouring and preserving. Most vinegar is made from coconut sap. Raw fish and crabs are consumed in various forms.

Wheat is not grown at all, yet bread, cakes and pastries are much liked. Dairy products are not much used. The carabaos (water buffalo), cows and goats are not milked. Whatever milk, butter or cheese are consumed are imported.

"Tuba", made by tapping the blossom stalk of the coconut tree and dyed with mangrove bark, is a very popular drink and is taken with every meal by most of the barrio people. It contains about 8% alcohol and is cheap (10 centavos, or 5 US cents, a pint bottle). Most children are given a sip early in life.

Leyte falls into the area of mild food deficiency (Spencer, 1951), and children have been regarded as receiving at best borderline nutrition Beriberi, infantile and adult, is reported; evidence of vitamin A deficiency in the form of xerosis, Bitot's spots and serious eye complications and resulting blindness is not uncommon. Protein deficiency in the form of hepatomegaly and oedema among children is in evidence.

EPIDEMIOLOGY

Historical Review

The occurrence of *Schistosoma japonicum* in the Philippines was first described by Wooley in 1906. Thereafter the infection was detected among the inmates of the Bilibid Prison in Manila, during the course of examination for intestinal helminths (in 1908 by Garrison and in 1914 by Willets), and among patients admitted to the Philippine General Hospital in 1928 (Hizon). The infected individuals were found to have come from the islands of Leyte, Samar, Mindanao and Luzon. Between 1906 and Tubangui's discovery of the intermediate snail host in 1932, cases of bilharziasis were detected by various authors in the Philippines.

As a large proportion of the discovered cases came from Leyte, Tubangui in 1932 visited the area in search of the intermediate host; he found *Oncomelania* sp. in a pond and a small brook in the barrio of Gacao in Palo. He was led by the proximity of the habitat to the residence of the infected individuals and succeeded in establishing that the snail was the intermediary host of the parasite. He was no doubt guided in his search of the snail by the previous discovery of *Oncomelania* sp. as the intermediate host of *S. japonicum* in Japan, China and Formosa. Tubangui's discovery in Palo marked the beginning of the fight against bilharziasis in the Philippines.

Africa & Garcia in 1935 planned the collection of information on the distribution of the disease in the Philippines through questionnaires sent out to the different hospitals in the country. Mindoro was added to the list of the endemic areas and some of the cases in Luzon were traced in Sorsogon. Africa drew pointed attention to the problem of bilharziasis in the Philippines in 1938. The first reliable field surveys were organized and reported on by the Bureau of Health of the Philippines in 1940 and 1941 in the islands of Mindanao, Leyte and Mindoro. Three small field units of the Bureau started detection and treatment of cases and attempted snail control by the use of unslaked lime and fire. The stools of over 3000 individuals were examined by direct smear in the three islands of Mindanao, Leyte and Mindoro, and prevalence rates of 6.2%, 8.8%, and 4.8%, respectively, were reported in the three islands.

Tubangui & Pasco in 1941 found an average prevalence rate of 20% in Mindanao, Leyte, Samar and Mindoro and reported dogs and pigs to be infected as well as humans. They made a rough estimate of between 25 000 and 33 000 human cases in the known endemic areas in the Philippines.

Africa & Garcia (1941) and Tubangui and associates (Tubangui & Aguila, 1941) continued research on the parasite and treatment of bilharziasis until war broke out in the Philippines in 1941, bringing all progress to a standstill. Paradoxically enough the same war brought the problem of bilharziasis to the forefront when an epidemic of the infection occurred among the United States forces landing in Leyte in October 1944. It involved over 1700 individuals (Wright, 1950). Starting in November, it reached its peak in January and died out in May 1945 (Carrol & Hunninen, 1948). A similar outbreak at about the same period (December to January) occurred among a Royal Australian Air Force airfield construction squadron, which had joined an American task force in Leyte (Dakin & Connellan, 1947). A diagnosis of bilharziasis was made in 174 of a total of 565 men who spent 16 days on the island.

A rush of papers appeared in the period 1945-47 on the Leyte experience, mostly on the clinical and pathological aspects of the disease relative to the protection of fighting forces, and at the same time some studies were made of the problem as it concerned the local population (Bang et al., 1945, 1946; Magath & Mathieson, 1945, 1946a, 1946b; Faust et al., 1946; Avery, 1946; McMullen, 1947; McMullen and Graham, 1947).

Bang & associates in 1945 reported 80% of children 10 years and older to be positive for *S. japonicum* in the five barrios surveyed in eastern Leyte, using the sedimentation technique. They considered the area to be hyperendemic and believed that everyone living in the area usually got infected before reaching the age of 15 years. Adults as a group, however, had a lower rate of infection than the children.

In 1947, Pesigan (1948a) found further endemic centres in Mindanao around Lake Mainit and obtained a prevalence rate of 21.6%, an estimate close to Tubangui's finding in 1941. The following year, he also established (Pesigan, 1948b) the endemicity of the disease in Irosin, Sorsogon, the first town in the island of Luzon to be so declared, which helped to focus the attention of the Philippine government on the problem of bilharziasis in the islands.

Tubangui (1948) by now had re-estimated that there were no less than 300 000 cases of bilharziasis in the country, basing his estimates on a liberal 20% average infection rate in the different endemic provinces. Wright (1950), however, placed the estimate at about 250 000. Wright et al. in 1947 had found the Mindanao provinces of Bukidnon, Lanao and Davao to be endemic, which led Pesigan and associates in 1949 to undertake further extensive surveys in that island, leading to the finding of cases in Cotabato, Occidental Misamis and Zamboanga (Pesigan, Pangilinan & Sarmiento, 1949).

Hunter and associates in 1950 surveyed Mindoro and, on the basis of two cover-slip preparations from direct smears and two from sediment of each faecal specimen, found a prevalence rate of 39.7% in the region west of Naujan Lake, and reported 8 out of 24 dogs, 9 out of 13 pigs and one out of 6 carabaos (water buffaloes) examined to be positive. This was the first time that the carabao, the most important draught animal in the Philippines, was reported to be a possible reservoir of *S. japonicum*.

During the period July 1949 to June 1950, under the auspices of the bilharziasis research programme established in the Department of Health of the Philippines, concerted efforts were made to survey the different endemic areas (Pesigan, 1950). Six field units were organized and they undertook mass stool examinations, snail surveys, treatment of patients, educational propaganda and snail control. This campaign covered 35 towns in 10 provinces in the islands of Mindanao, Leyte, Mindoro and Samar. Of the 35 509 individuals examined by the direct single faecal smear method, 4302 found positive for bilharziasis, giving a prevalence rate of 12.1%. The worst affected areas found were: Aurora in Zamboanga; Bonifacio in Occidental Misamis; Naujan in Mindoro; Mainit in Surigao; Butuan City and Jabonga in Agusan; Bobon in Samar; and almost all the towns surveyed in Leyte, with the prevalence rate reaching as high as 50.7% in the newly created town of McArthur, Leyte, formerly barrio Tarragona.

Another important feature of this survey was that a report was also made on the exceedingly high prevalence rate of intestinal helminths in the areas surveyed, which reached a figure of nearly 99% both in the bilharziasis-affected and in the free areas. Age and sex distribution of the schistosome-infected individuals and their clinical gradation into five categories, depending on the stage of disease, was presented by Pesigan in 1951. Almost 90% of the samples examined by the field units (except Mindoro Unit No. 3) were, however, schoolchildren; therefore a true picture in the total population could not be obtained, but a higher prevalence among males than among females was apparent.

Following this survey the importance of the problem of bilharziasis in the Philippines came to be recognized, and the Philippine Government created the Division of Schistosomiasis in the Department of Health in 1951. At the request of the Government, the World Health Organization sent a team of consultants to the Philippines in 1952. The terms of reference of this team were: (1) to study the bilharziasis problem in the Philippine

Islands; (2) to examine the control work that was being done; and (3) to make recommendations for a national programme. The team spent approximately three months studying the problem and submitted a very valuable report in which the problem of bilharziasis in the Philippines was described as an extremely complicated one. An estimate of 100 000 to 200 000 cases in the 12 endemic areas of the Philippine Islands was made; this figure was, however, revised to 200 000–300 000 in 1954 (McMullen et al., 1954). The team felt that the disease problem had so far been approached almost entirely from a medical viewpoint, which was but a small segment of the whole, and that, in order that control should be successful, it was necessary to get more information on all aspects of the problem, including biology, engineering, agriculture and education. It was also considered that thinly spread efforts to deal with the disease would be more or less unrewarding, and therefore suggested that they should be terminated and an attack made on the problem from a new angle. The team therefore recommended the concentration of funds and efforts on a pilot project, with the World Health Organization providing three advisers for the programme and the Division of Schistosomiasis supplying opposite numbers, technicians, assistants and labourers.

The team suggested that parts of eastern Leyte, which appeared to be the most important endemic area, be used for a pilot project of six years' duration, with an absolute minimum of three years.

Objectives of the Pilot Project

The Philippine Government acted quickly on the recommendation of the WHO bilharziasis team made in September 1952, in initiating a bilharziasis control project in Leyte, and WHO assisted the project by supplying three international personnel. Assistance was also received from the Foreign Operations Administration of the USA in the form of supplies and from the Philippine Council for United States Aid. A fully equipped project-centre building, including laboratories, was constructed and staffed, and the project officially started functioning in June 1953.

The project has the following objectives:

" 1. To determine the most effective and economical means of controlling bilharziasis in the Philippines.

" 2. To train local professional and auxiliary personnel in the various phases of the work envisaged in this project.

" 3. To conduct studies and make observations on the human, other vertebrate and snail hosts of *Schistosoma japonicum* as well as on the parasite itself; to obtain data essential for the rational control of the disease.

" 4. To make a thorough epidemiological study of the disease in a highly endemic area.

" 5. To design and test control measures based on the results of data obtained by basic studies and observations.

" 6. To plan and prepare for an expanded bilharziasis control programme ".

Choice of Areas

The prevalence of bilharziasis in man and the other animal reservoir hosts has been determined in the municipalities of Palo, Tanauan and Carigara and in the barrio of Bagahupi (see Fig. 2).

Palo is the headquarters of this project and serves as an area for (*a*) epidemiological studies on the human host and animal reservoirs; (*b*) ecological studies on the intermediate snail host; (*c*) development of control methods and evaluation procedures and for control operations and demonstration; and (*d*) continued observations and a training centre.

Tanauan, contiguous to Palo and similar in character, size and other relevant respects, serves as a control area. This area will furnish, during and after the period of operations in Palo, epidemiological data which may be compared (*a*) with those for Palo and (*b*) with later data for Tanauan when, in the following years, the area will have been partly included in the operations programme.

Carigara was originally chosen as an altogether bilharziasis-free area on the northern coast of Leyte, 41 km north of Palo, to serve as an additional check area to compare and contrast general health conditions and other ecological differences from Palo and Tanauan. During the detailed survey a few individuals in some of its barrios and some field rats were found infected. An infected snail colony has been found just outside its political limits. But because of its similarity in all other relevant respects to Palo, we have decided to retain it to serve its original purpose and to interpret finding with due precautions.

Bagahupi, a newly opened up area, conveniently situated 30 km north of Palo, and endemic for bilharziasis, was selected to try out an energetic community development programme directed mainly towards the elimination of infection by all the methods developed.

The main epidemiological features of bilharziasis in each of these areas are briefly presented with fuller discussion of the situation in Palo.

Census Data And Sampling

Census data

Before deciding on samples for surveys from which we could draw valid conclusions about the entire population, we had no alternative but to conduct a census of the entire pilot area in Palo and the control area in Tanauan. The areas were first mapped out and divided into convenient zones, based not on any political boundaries but on geographical location and convenience of size of the area. The census taken included the main characteristics of the population, numbers of different animal reservoirs, as being of special relevance to our study, and the sanitary conditions. The staff employed was briefed about collection of data on a prescribed form.

Data on human population have been classified to provide information on the number of houses and families, population (with age and sex composition) and occupation. In relating disease frequency to population characteristics and environmental differences, the pilot area has been divided into three divisions: the " población ", the " coastal " and the " inland ", on the basis of apparent topographic and demographic differences. The census data have been classified under these three environmental divisions, subdivided into zones.

It has been very difficult, or impossible, to obtain any reliable data on income on which to base a classification into economic groups. Information on occupation was gathered, but difficulty is felt in many cases in allocating individuals into any rigid classification, because of the fact that people in this area mostly follow more than one occupation. Farming, fishing, tuba-gathering or working as unskilled labourers in the case of men and housekeeping, nipa-weaving and running a " sari-sari " (miscellaneous provisions) store for women are not uncommon combinations. However, in taking the census the principal activity was noted as the occupation. The essential data for the four areas surveyed are briefly tabulated in a comparative summary (Table VI).

Data on the animal population of Palo and Tanauan have been classified in Tables VII and VIII. Animal density is expressed as a proportion of the number of animals to houses in the area. Pigs are ubiquitous domesticated animals; there is approximately one pig for each house, uniformly distributed in the three divisions of Palo. There is a dog and a carabao (water buffalo) for nearly every other house. Dogs are most numerous in the inland area and least in the población, where the need for protection is less. Carabaos are least numerous in the coastal area, not being in demand with the fishermen and tuba gatherers of the area. Goats are few and are found predominantly in the coastal areas. There are only 76 cows in the pilot area of Palo, of which 38 are in the población. There are very few horses (37), and they are poor, stunted animals.

In general, a similar pattern of animal distribution is noticed in Tanauan. On an average there is a pig for each household, and a dog for very other house. There are more carabaos, however, in Tanauan than in Palo, there being three carabaos to four houses in Tanauan compared to one for two houses in Palo. There are very few goats, cows or horses in Tanauan.

The number of pigs, however, will vary, depending on how close to a " fiesta " the census has been taken—this stock is very much depleted during the period following these annual feasts (mostly in the months of May-June in Palo municipality) because of the ubiquitous " lechón " (roast pig) without which no festive occasion is complete. But as the census

TABLE VI. SUMMARY OF CENSUS DATA FOR PALO, TANAUAN, CARIGARA AND BAGAHUPI

Town	Number of houses	Number of families	Population	Number of persons per house	Percentage of population under 20 years	Proportion of males to females	Main occupation	Number of animals per house	Percentage of houses with latrines
Palo	2 832	2 876	14 819	5.2	53.0	93 : 100	Men : farmers, unskilled labourers and jobless. Women : housekeeping.	2.7	50.3
Tanauan	2 707	2 753	12 081	4.5	50.2	102 : 100	Men : farmers, fishermen and jobless. Women : housekeeping.	3.5	20.8
Carigara	2 857	2 903	15 346	5.4	55.0	97 : 100	Men : farmers, fishermen and jobless. Women : housekeeping.	2.6	25.1
Bagahupi	142	143	822	5.8	58.7	108 : 100	Farmers and jobless	2.3	14.1

TABLE VII. DISTRIBUTION OF ANIMAL RESERVOIR POPULATION IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and divisions	Number of houses	Pigs		Dogs		Carabaos		Cats		Goats		Cows		Horses	
		number	number per house	number	number per house	number	number per house	number	number per house	number	number per house	number	number per house	number	number per house
Palo	2 832	3 193	1.1	1 517	0.5	1 318	0.5	1 397	0.5	204	0.1	76	0.03	37	0.01
Población	1 548	1 740	1.1	733	0.5	774	0.5	681	0.4	78	0.1	38	0.02	12	0.01
Coastal	806	905	1.1	443	0.5	287	0.4	419	0.5	102	0.1	29	0.04	8	0.01
Inland	478	548	1.2	341	0.7	257	0.5	297	0.6	24	0.1	9	0.02	17	0.04

TABLE VIII. DISTRIBUTION OF ANIMAL RESERVOIR POPULATION IN TANAUAN AND ITS THREE DIVISIONS (1953-54)

Town and divisions	Number of houses	Pigs		Dogs		Carabaos		Cats		Goats		Cows		Horses
		number	number per house	number	number per house	number	number per house	number	number per house	number	number per house	number	number per house	
Tanauan	2 707	3 764	1.4	1 762	0.7	2 094	0.8	1 934	0.7	8	0.003	12	0.004	
Población	238	926	2.9	252	1.1	295	1.2	393	1.7	3	0.01	11	0.05	nil
Coastal	790	901	1.1	476	0.6	493	0.6	550	0.7	2	0.003			
Inland	1 679	1 937	1.2	1 034	0.6	1 306	0.8	991	0.6	3	0.002	1	0.001	

was spread over a period of approximately one full year, we feel satisfied that the figures for pigs are fairly representative.

Our attempts to determine the size of the rodent population proved unsuccessful, and we were forced to assume as a working formula a number of ten rodents per person in the pilot area, which works out at 60 per hectare; this, we feel, is not too wild a guess for this region.

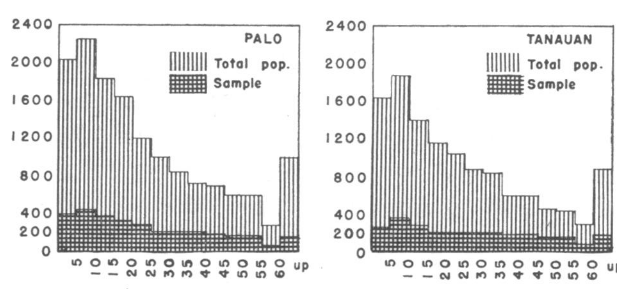
Information has been gathered on the provision of latrines; the numbers and percentages of houses with latrines in Palo and Tanauan are as follows:

		Palo	*Tanauan*
Población	Number	1020	23
	Percentage	65.9	9.7
Coastal	Number	327	144
	Percentage	40.5	18.2
Inland	Number	77	395
	Percentage	16.1	23.5
Total	Number	1424	562
	Percentage	50.3	20.8

Sampling

In determining the prevalence of schistosome and other helminthic infections, the samples of 2909 individuals screened in the pilot area of Palo and 2246 in the control area of Tanauan were allocated proportionately in the age-stratified population of the different environments. Age stratification was based on the census as shown in Tables IX and X.

FIG. 7. AGE DISTRIBUTION OF POPULATION AND SAMPLES EXAMINED IN PALO AND TANAUAN



The graph in Fig. 7 shows the size of the sample in relation to the total population in Palo and Tanauan. The sample included approximately 20% of the population in the two areas. These fair-sized samples have allowed the differential observations, in the manifold classifications required, to be significant and generalizations to be valid.

TABLE IX. AGE COMPOSITION OF POPULATION AND OF THE SAMPLE EXAMINED IN PALO AND ITS THREE DIVISIONS (1953-54)

Age-group (years)	Palo				Población				Coastal				Inland			
	population		sample examined		population		sample examined		population		sample examined		population		sample examined	
	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total
Below 5	2 053	13.9	386	13.3	1 060	12.8	138	12.2	619	15.0	131	14.2	374	15.8	117	13.6
5–9	2 278	15.4	455	15.6	1 179	14.2	159	14.1	678	16.4	143	15.5	421	17.8	153	17.8
10–14	1 852	12.5	384	13.2	1 029	12.4	136	12.1	494	11.9	122	13.2	329	13.9	126	14.7
15–19	1 648	11.1	302	10.4	986	11.9	138	12.2	428	10.3	88	9.5	234	9.9	76	8.9
20–24	1 212	8.2	218	7.5	699	8.4	86	7.6	345	8.3	76	8.2	168	7.1	56	6.5
25–29	1 007	6.8	207	7.1	573	6.9	82	7.3	276	6.7	57	6.2	158	6.7	68	7.9
30–34	865	5.8	186	6.4	500	6.0	73	6.5	221	5.3	58	6.3	144	6.1	55	6.4
35–39	756	5.1	168	5.8	404	4.9	60	5.3	219	5.3	52	5.6	133	5.6	56	6.5
40–44	689	4.6	155	5.3	373	4.5	55	4.9	196	4.7	56	6.1	120	5.1	44	5.1
45–49	591	4.0	129	4.4	357	4.3	60	5.3	165	4.0	38	4.1	69	2.9	31	3.6
50–54	605	4.1	124	4.3	381	4.6	53	4.7	144	3.5	35	3.8	80	3.4	36	4.2
55–59	299	2.0	54	1.9	179	2.2	21	1.9	78	1.9	16	1.7	42	1.8	17	2.0
60 and over	964	6.5	141	4.8	588	7.1	67	5.9	277	6.7	51	5.5	99	4.2	23	2.7
Total	14 819	100	2 909	100	8 308	100	1 128	100	4 140	100	923	100	2 371	100	858	100

TABLE X. AGE COMPOSITION OF POPULATION AND OF THE SAMPLE EXAMINED IN TANAUAN AND ITS THREE DIVISIONS (1953-54)

Age-group (years)	Tanauan				Población				Coastal				Inland			
	population		sample examined		population		sample examined		population		sample examined		population		sample examined	
	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total	number	percentage of total
Below 5	1 632	13.5	261	11.6	181	15.4	32	15.5	511	13.8	76	11.1	940	13.1	153	11.3
5–9	1 870	15.5	355	15.8	173	14.7	27	13.0	552	14.9	104	15.2	1 145	15.9	224	16.5
10–14	1 403	11.6	284	12.6	135	11.5	27	13.0	447	12.0	73	10.7	821	11.4	184	13.6
15–19	1 163	9.6	192	8.6	116	9.9	17	8.2	393	10.6	61	8.9	654	9.1	114	8.4
20–24	1 024	8.5	78	7.9	116	9.9	24	11.6	315	8.5	48	7.0	593	8.2	106	7.8
25–29	869	7.2	169	7.5	90	7.7	14	6.8	264	7.1	59	8.6	515	7.2	96	7.1
30–34	820	6.3	167	7.4	86	7.3	15	7.2	250	6.7	56	8.2	484	6.7	96	7.1
35–39	622	5.1	143	6.4	56	4.8	12	5.8	165	4.4	44	6.4	401	5.6	87	6.4
40–44	607	5.0	125	5.6	39	3.3	8	3.9	176	4.7	34	5.0	392	5.4	83	6.1
45–49	466	3.9	86	3.8	39	3.3	8	3.9	137	3.7	25	3.7	290	4.0	53	3.9
50–54	443	3.7	83	3.7	45	3.8	5	2.4	133	3.6	31	4.5	265	3.7	47	3.5
55–59	267	2.2	53	2.4	26	2.2	4	1.9	84	2.3	22	3.2	157	2.2	27	2.0
60 and over	895	7.4	150	6.7	71	6.1	14	6.8	283	7.6	51	7.5	541	7.5	85	6.3
Total	12 081	100	2 246	100	1 173	100	207	100	3 710	100	684	100	7 198	100	1 355	100

In the case of Carigara and Bagahupi the sample screened was not on the basis of age stratification but it was randomized by examining all individuals in every tenth house in the communities surveyed. A total of 1656 individuals were screened in Carigara and 177 in the barrio of Bagahupi, representing nearly 11% and 22% of the total populations, respectively. Table XI summarizes the sample size in the four areas surveyed.

TABLE XI. SAMPLE SIZE, PROPORTION TO TOTAL POPULATION AND METHOD OF SAMPLING EMPLOYED IN THE FOUR AREAS SURVEYED

Town	Number examined	Percentage of total	Method of sampling used	Period of survey
Palo	2 909	19.63	Age stratified in each zone	February 1953—July 1954
Tanauan	2 246	18.6	Age stratified in each zone	February 1953—February 1954
Carigara	656	10.9	All individuals from every 10th house in the area	October 1954—May 1955
Bagahupi	177	21.5	All individuals from every 5th house in the area	September 1955

Sampling procedure for the two longitudinal studies on the natural history of the disease (see page 412) have been described in the sections concerned for the sake of clarity and continuity of description of the materials and methods employed.

The animals examined for the determination of prevalence and in connexion with their relative role in the transmission of the disease were taken at random over the different zones of the areas surveyed.

Techniques

Techniques for demonstrating *S. japonicum* eggs in stools

Qualitative

Pesigan & Yogore (1947) evaluated the relative efficacy of direct faecal smear, acid ether sedimentation and Faust-Meleney egg-hatching techniques and came to the conclusion that the latter, using 5-10 g of the faeces sample, is the most efficient in demonstrating the presence of *S. japonicum* eggs. They recognized, however, the value of the acid ether technique when the time factor was important or when the stools were no longer fresh. They recommended the additional examination of the sediment for dead miracidia, empty egg-shells and unhatched immature or degenerated eggs, before a sample was regarded as negative, and advocated the performance of a combination of techniques, not excluding the direct faecal smear.

The standard method adopted in this project is a combination of techniques, using 5 cm^3 of freshly passed faecal specimen collected in paraffin-coated cardboard containers in the morning, with examination begun within three hours of the collection of the specimens. This standard method includes a combination of the following:

1. One direct faecal smear (2 cover-slip preparations).
2. Glycerol sedimentation using 0.5% glycerol in tap-water and examination of the entire sediment.
3. Hatching of sediment from 2.
4. Examination of sediment from 3.

The efficacy of another sedimentation technique, using 10% ethyl alcohol (Jahnes & Hodges, 1947), was tested against the standard method. Comparative results obtained from an examination of 677 stools are presented in Table XII.

TABLE XII. COMPARATIVE EFFICIENCY OF SEDIMENTATION AND EGG-HATCHING TECHNIQUES USING 0.5% GLYCEROL AND 10% ETHYL ALCOHOL

Techniques	Number positive	Percentage positive	Relative efficiency (359 positive as 100 %)
Glycerol sedimentation, egg-hatching, and sediment after hatching	349	51.6	97.2
Sedimentation alone	234	34.6	65.2
Egg-hatching alone	254	37.5	70.8
Sediment after hatching alone	220	32.5	61.3
Alcohol sedimentation, egg-hatching and sediment after egg-hatching	311	45.4	86.6
Sedimentation alone	194	28.7	54.0
Egg-hatching alone	213	31.5	59.3
Sediment after hatching alone	225	33.2	62.7

Taking the total positive by both techniques (359) to represent 100%, relative efficiency values of 97.2% for glycerol sedimentation and 86.6% for alcohol sedimentation was obtained. The results are in favour of the former method.

The other two techniques that have been compared at different times with our standard method were: AMS III (Army Medical School III) described by Hunter et al. (1948) and MIFC (merthiolate-iodine-formaldehyde concentration) described by Blagg et al. (1953).

Tables XIII and XIV present data on the relative values of these techniques in comparison with the standard method.

TABLE XIII. COMPARATIVE EFFICIENCY OF AMS III AND STANDARD METHOD OF STOOL EXAMINATION FOR SCHISTOSOME OVA AMONG 103 INDIVIDUALS EXAMINED

Techniques	Number positive	Percentage positive	Relative efficiency (72 positive as 100 %)
1. Direct faecal smear	22	21.3	30.5
2. 0.5 % Glycerol sedimentation	67	65.0	93.0
3. Egg-hatching	63	61.1	87.5
4. Sediment after egg-hatching	53	51.4	73.6
5. Standard method (combination of methods 1-4)	67	65.0	93.0*
6. AMS III	46	44.6	63.0

* Minimum assumed

The total number examined by AMS and the standard method for comparison was 103, and taking 72 positive by both techniques to represent 100 %, the relative efficiency was determined to be 63 % and 93 % respectively, the difference being highly significant in favour of the standard method.

TABLE XIV. COMPARATIVE EFFICIENCY OF MIFC AND STANDARD METHOD OF STOOL EXAMINATION FOR SCHISTOSOME OVA AMONG 897 INDIVIDUALS EXAMINED

Techniques	Number positive	Percentage positive	Relative efficiency (259 positive as 100 %)
1. Direct faecal smear	89	11.0	34.4
2. Glycerol sedimentation	203	25.2	78.4
3. Egg-hatching	139	17.2	53.7
4. Sediment after egg-hatching	167	20.7	64.5
5. Standard method (combination of methods 1-4)	217	26.9	83.8
6. MIFC	232	28.7	89.6

The total number of stools in the comparison of the MIFC technique was 897, of which 259 were positive by both techniques. Relative efficiency of the standard method was 83.8%, against 89.6% for MIFC (Table XIV).

We have found the MIFC technique to be very useful in epidemiological surveys, being a preservative, rapid and reliable test for screening a large number of samples every day. The standard method, however, has the advantage of allowing observations on the viability of eggs and requires fewer chemicals and no centrifuge and can be performed away from any equipped laboratory. These two, therefore, appear to us to be the methods of choice for surveys for *S. japonicum*. We now utilize one or the other of the two methods as circumstances dictate, and since the efficiency of the two procedures is not appreciably different, the results obtained by either technique can be compared without biasing conclusions.

Quantitative techniques to determine " worm-burden "

For quantitative estimation of helminth eggs, the following three methods were evaluated:

1. Stoll technique, using 3 ml of faeces.
2. MIFC egg count in total sediment, using 1 ml of faeces.
3. MIFC (modified) examination of 0.2 ml of sediment from No. 2.

In the first method, 3 ml of well-mixed faeces are measured by adding enough of 0.1N sodium hydroxide till the 30-ml mark is reached. The whole is mixed and the resulting emulsion made up to 90 ml by further addition of 0.1N NaOH. After vigorous shaking 0.3 ml of the emulsion is examined and the ova counted. This count times 100 gives the number of ova per ml of faeces.

A total of 113 stools were examined by the three methods mentioned, and the results obtained showed that Stoll's technique is more efficacious as far as egg counts for the intestinal helminths are concerned, whereas the MIFC (using 1 cm^3 of faeces) is superior and easier to conduct as far as *Schistosoma* eggs are concerned. We have, therefore, adopted these two methods for quantitative determination of eggs in stools in our studies.

Intradermal test

The only immunological test which we have evaluated as of possible use in epidemiological surveys is the intradermal test.

The antigen is prepared by a certain modification of the technique adopted by Gonzales & Pratt (1944) described by Pesigan et al. (1951a). The method of testing followed was the same as the one described by Pesigan et al. (1954) in the Philippines, establishing its value in mass screening surveys for *S. japonicum* infection. Out of a series of 1051 stool-positive

TABLE XV. PREVALENCE OF BILHARZIASIS BY AGE IN MALIRONG AND BARAS ZONES IN PALO AS DETERMINED BY INTRADERMAL TEST * (1953-54)

Age-group (years)	Malirong					Baras				
	number examined	number positive	percentage positive	number doubtful	percentage doubtful	number examined	number positive	percentage positive	number doubtful	percentage doubtful
Below 5	84	2	2	1	1	35	0	0	0	0
5–9	104	23	22	8	8	75	11	15	4	5
10–14	73	45	62	6	8	99	55	56	4	4
15–19	31	24	77	1	3	47	30	64	4	9
20–24	38	31	82	4	11	35	28	80	0	0
25–29	31	25	81	1	3	30	26	87	2	7
30–34	35	28	80	2	6	28	21	75	1	4
35–39	24	21	88	0	0	17	12	71	1	6
40–44	30	27	90	1	3	34	29	85	2	6
45–49	14	12	86	0	0	20	18	90	1	5
50–54	16	10	63	3	19	20	14	70	1	5
55–59	7	6	86	0	0	10	7	70	1	10
60 and over	21	17	81	1	5	19	15	79	0	0

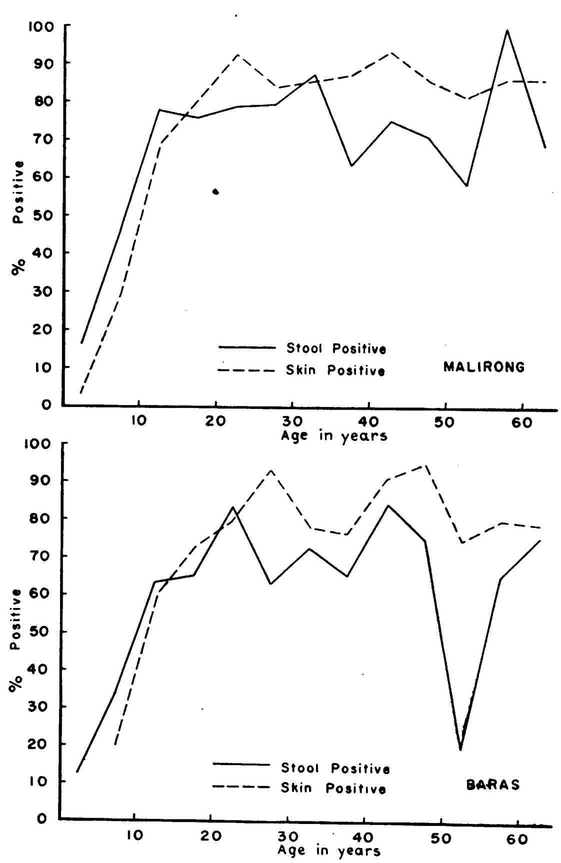
* 0.05 ml of 1:5000 dilution of adult fluke antigen used.

individuals examined by them in the different provinces of the Philippines, 93.9% were found positive, including 9.8% doubtful positives to the intradermal test. False positive reactions were 2.7%.

In two zones in Palo, the one in the inland area with the higher prevalence rate (Malirong, 63.0%), and the other in the coastal area with the lower prevalence rate (Baras, 54.3%), the intradermal test was repeated to compare age prevalence rates as determined by the two methods in areas with different rates of endemicity. Skin tests were performed on 508 individuals, varying in age and sex, in Malirong and 469 in Baras, using 0.05 ml of the 1/5000 dilution of the adult fluke antigen.

The results of the test are noted in Table XV and it will be seen that the number of positive reactors increases with age until the peak is reached in the age-group 20-24 years, and thereon, though fluctuations in the curve occur,

FIG. 8. COMPARISON OF RESULTS OF INTRADERMAL TEST AND STOOL EXAMINATION BY AGE-GROUPS IN MALIRONG AND BARAS, PALO, 1953-54



the general tendency is for it to remain stationary. Comparing the curves in Fig. 8 for the results of the skin test with those of the stool test, both for Malirong and Baras, it will be noted that there is a lag in the rise of the skin test curve for ages under 15, at which point the two curves cross over, with a greater percentage of skin reactors than positives stools in older ages. This may be due to the volume and dilution of the antigen being insufficient to elicit a positive reaction in children exposed to repeated infections, in whom the antigen is possibly in excess of the antibodies produced and which therefore neutralizes them and does not permit skin sensitization to develop (WHO Expert Committee on Bilharziasis, 1953). The youngest child found positive by the intradermal test in our series was 3 years old and the youngest child found positive by the stool test was 2 years old.

In conclusion, the skin test, though not an evidence of active infection, is of special value as a rapid screening method in the field for bilharziasis. The degree of skin sensitivity increases with age. Though infection among children may be missed with this test, up to 90% of infections in adults can be detected.

The Palo Area

Palo, is situated 12 km south of the capital city of Tacloban. It is one of the four first-class municipalities in the province of Leyte, with a total population of 25 471 living in its población and its 21 barrios. It is partly urban but mostly rural in character. As to socio-economic conditions, it can be regarded as typical of the towns in eastern Leyte, except for the fact that it enjoys such additional amenities as proximity to the capital city of the province provides. Palo, being the central point of departure into the interior of Leyte, has quite heavy road traffic.

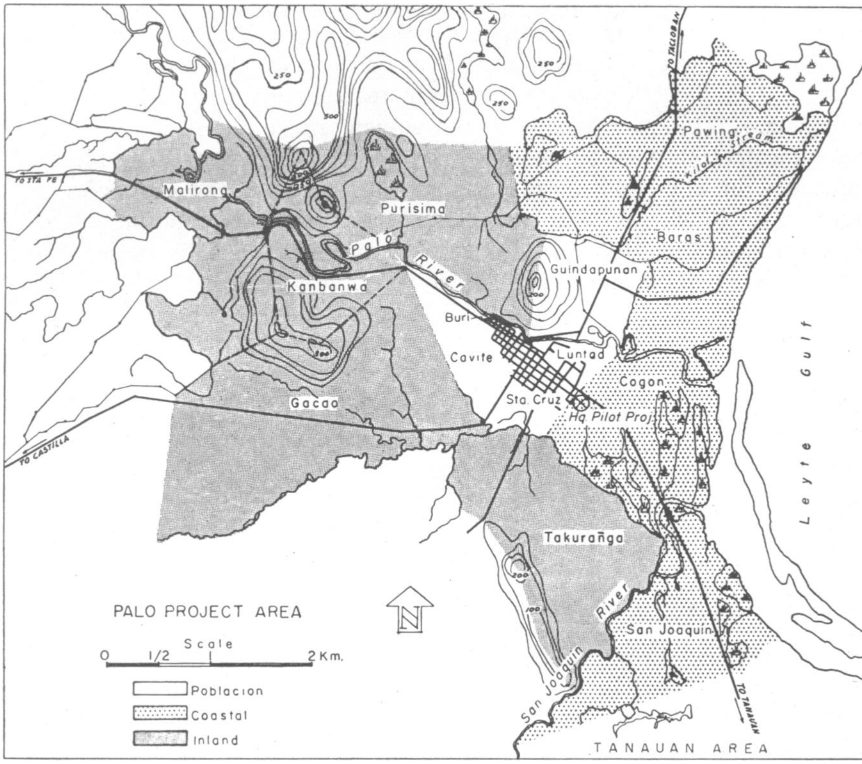
A major portion of the municipality of Palo (25.5 km^2) has been delineated to serve as the pilot project area, and for purposes of census and surveys has been divided into 14 convenient zones with a total population of nearly 15 000.

Fig. 9 shows the pilot project area of Palo. It is bounded on the north by hills and the city of Tacloban, on the south by Tanauan, on the west by the municipality of Pastrana, and on the east by the Leyte Gulf.

Reference to the age composition of the population (Table IX) will show that over 40% of the people are under 15, and over 80% below 45 years of age. The population, therefore, should be regarded as predominantly youthful, with a high proportion of young children. For considerations mentioned in the previous section, Palo is divided into the población, the coastal division and the inland divisions.

The *población* in Palo is wedged between the coastal and the inland areas and is mainly urban in character, but the outskirts assume rural

FIG. 9. PILOT PROJECT AREA IN PALO, SHOWING ENVIRONMENTAL DIVISIONS



characteristics and it becomes difficult to say where the one ends and the other begins. It contains more than half the population within the pilot area of Palo, made up mainly of small businessmen, employees of the municipality, farmers and a few carpenters.

The población has a rural health unit and a maternity house with 30 beds and two well equipped delivery rooms, built in 1951. The rural health centre fits into the general pattern of rural health services described. A piped water supply from the water main to Tacloban City from a catchment area in the hills of Dagami, 30 km south of this town, is available. It is not filtered or chlorinated regularly. Approximately two-thirds of the houses have latrines, mostly of the " antipolo " pit type.

The soil types are mostly of the Palo clay series (see page 353) and there are two comparatively small snail colonies within this division.

The *coastal division* is fairly extensive and is divided into four zones. It has an extensive shore line, the southern half being separated from the sea by a long shifting sand-bar across the mouths of the two main rivers—the Palo and the San Joaquín.

The area is typically rural, with extensive lowland rice-fields in the northern half. The southern half of this area, Cogon and San Joaquín zones, has extensive brackish-water nipa swamps.

Fishing is the main industry of the area, which is combined with lowland rice farming of the primitive type described. Tuba-gathering for men and mat-weaving for women are important occupations in the two northern zones (Pawing and Baras), just as for women making nipa shingles, and for men fishing and diving for salvaging of wartime ammunition dumped into the river, are the common occupations in the southern zones.

Fine sandy loam soil predominates in the area, with no stones or boulders of any kind on the surface or in the substratum. Grasses and sedges are the dominant forms of plants, which grow luxuriantly. Subsoil water reaches almost to the surface in places, making the soil boggy so that work animals nearly sink In areas close to the boundary of other soil types lowland rice is grown. Fish-ponding is popular in the northern zone of Pawing.

There is one extensive snail colony along a stream in the north (Kilot) and another group of colonies in Cogon zone. The brackish nipa swamps of the south have no snails.

The general impression obtained of the people is that they are, compared to those in the interior, better off economically, and seem better fed. The housing is generally superior. Fish is an important article of diet; root crops do not do well in the type of soil described.

The medical officer of the rural health unit holds two clinics a week in this area at Pawing and San Joaquín. Some 41 % of houses have latrines, mostly of the " antipolo " pit type.

The *inland division* has a population of 2371, spread over an extensive area divided into five zones. The housing, living conditions, and sanitation are typical of any other rural area in Leyte and could be described as backward compared to the población or the coastal division.

The main industry is lowland rice farming and copra-making. Root crops, corn and some tobacco and vegetables are grown in places.

The soil is typically Palo clay and sandy loam with patches of San Manuel silt loam. There are outcrops of hills in many areas. The area is traversed by several streams and many places with poor drainage are water-logged. Many extensive snail colonies are located in this area.

The medical officer of the rural health unit in Palo conducts a weekly clinic in Malirong zone. The general sanitation of the area is the poorest of all the three divisions of Palo. Only 16 % of houses have latrines, of the pit type.

Prevalence of Schistosome Infection in Man and Relationship to Age, Sex, Occupation and Environment

Palo

The age distribution of the infection in the pilot area of Palo and its three environmental divisions is given in Table XVI. Of the total 2909

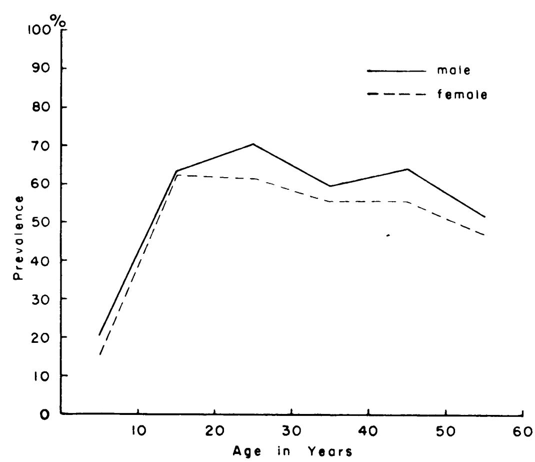
TABLE XVI. AGE PREVALENCE OF SCHISTOSOME INFECTION IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)										Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–44	45–54	55 and over	
Palo											
Number examined	386	455	384	302	218	207	186	323	253	195	2 909
Number schistosome-positive	18	135	230	201	155	125	110	193	130	98	1 395
Percentage schistosome-positive	4.7	29.7	59.9	66.6	71.1	60.4	59.1	59.8	51.4	50.3	48.0
Población											
Number examined	138	159	136	138	86	82	73	115	113	88	1 128
Number schistosome-positive	3	32	69	83	55	40	31	56	49	35	453
Percentage schistosome-positive	2.2	20.1	50.7	60.1	64.0	48.8	42.5	48.7	43.4	39.8	40.2
Coastal											
Number examined	131	143	122	88	76	57	58	108	73	67	923
Number schistosome-positive	4	25	66	56	58	37	35	67	35	35	418
Percentage schistosome-positive	3.1	17.5	54.1	63.6	76.3	64.9	60.3	62.0	47.9	52.2	45.3
Inland											
Number examined	117	153	126	76	56	68	55	100	67	40	858
Number schistosome-positive	11	78	95	62	42	48	44	70	46	28	524
Percentage schistosome-positive	9.4	51.0	75.4	81.6	75.0	70.6	80.0	70.0	68.7	70.0	61.1

individuals examined, 48.0% were found infected. The infection during childhood and adolescence builds up rapidly until it reaches a peak of 71.1% in the age-group 20-24 years and thereafter a general downward trend follows.

Age and sex distribution of infected individuals is shown in Table XVII and Fig. 10. There are significant sex differences between age-groups past childhood, with the rates being higher for males than for females, the over-all rate being 49.6% for males and 46.4% for females. Children of both sexes run an equal risk but the difference begins to show up after 14 years, by which time males become more active in the field and run greater chances of acquiring the infection.

FIG. 10. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN PALO, 1953-54



Prevalence in respect of occupation in Palo must be interpreted with care as the people in this area usually engage in more than one activity and it is usually difficult to allocate them rigidly to one professional class. In Table XVIII, therefore, classification has been based on the main occupation. The farmers as a class have the highest infection rate (74.1%). When not planting or harvesting rice, they engage themselves as fishermen, unskilled labourers or tuba-gatherers, which would explain the next highest prevalence being among this group of professions—over 60% in Palo. The occupations that would bring people most in contact with infected waters are farming and inland fishing. Seagoing fishermen, who live mostly in the coastal division, would run less occupational hazards than the inland fishermen who would naturally be the people most exposed to infection in rivers, swamps and streams. The infection rates of fishermen

TABLE XVII. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)												Total	
	below 10		10–19		20–29		30–39		40–49		50 and over			
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
Palo														
Number examined	439	402	331	355	195	230	155	199	138	146	138	181	1 396	1 513
Number schistosome-positive	91	62	209	222	139	141	93	110	90	81	71	86	693	702
Percentage schistosome-positive	20.7	15.4	63.1	62.5	71.3	61.3	60.0	55.3	65,2	55.5	51.4	47.5	49.6	46.4
Población														
Number examined	145	152	135	139	73	95	61	72	49	66	65	76	528	600
Number schistosome-positive	17	18	71	81	42	53	28	29	30	28	32	24	220	233
Percentage schistosome-positive	11.7	11.8	52.6	58.3	57.5	55.8	45.9	40.3	61.2	42.4	49.2	31.6	41.7	38.8
Coastal														
Number examined	147	127	97	113	64	69	46	64	48	46	43	59	445	478
Number schistosome-positive	15	14	57	65	52	43	30	32	32	29	19	30	205	213
Percentage schistosome-positive	10.2	11.0	58.8	57.5	81.3	62.3	65.2	50.0	66.7	63.0	44.2	50.8	46.1	44.6
Inland														
Number examined	147	123	99	103	58	66	48	63	41	34	30	46	423	435
Number schistosome-positive	59	30	81	76	45	45	35	49	28	24	20	32	268	256
Percentage schistosome-positive	40.1	24.4	81.8	73.8	77.6	68.2	72.9	77.8	68.3	70.6	66.7	69.6	63.4	58.9

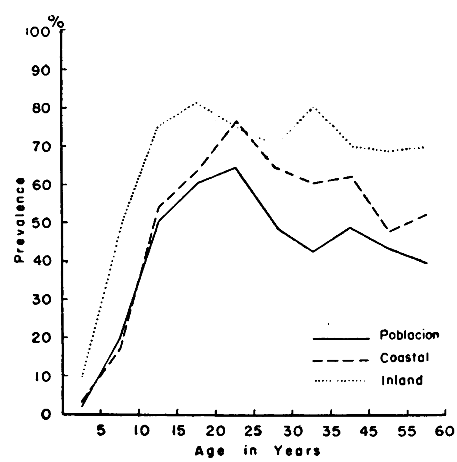
TABLE XVIII. PREVALENCE OF SCHISTOSOME INFECTION IN THE DIFFERENT OCCUPATIONAL GROUPS IN PALO AND ITS THREE DIVISIONS (1953-54)

Occupation	Palo			Población			Coastal			Inland		
	number examined	number positive	percentage positive	number examined	number positive	percentage positive	number examined	number positive	percentage positive	number examined	number positive	percentage positive
Pre-school	580	56	9.7	200	12	6.0	191	9	4.7	189	35	18.5
Student	617	342	55.4	272	124	45.6	185	96	51.9	160	122	76.3
Housekeeper	738	431	58.4	283	139	49.1	240	137	57.1	215	155	72.1
Farmer	197	146	74.1	67	44	65.7	21	16	76.2	109	86	78.9
Tuba-gatherer	15	10	66.7	3	3	100.0	4	2	50.0	8	5	62.5
Fisherman	22	15	68.2	6	4	66.7	10	6	60.0	6	5	83.3
Unskilled labourer	252	169	67.1	65	38	58.5	128	88	68.8	59	43	72.9
Skilled labourer	44	21	47.7	24	11	45.8	18	9	50.0	2	1	50.0
Shopkeeper	23	12	52.2	16	8	50.0	4	2	50.0	3	2	66.7
Office worker	39	10	25.6	32	7	21.9	3	1	33.3	4	2	50.0
Professional	37	6	16.2	26	5	19.2	8	0	0	3	1	33.3
Jobless	345	177	51.3	134	58	43.3	111	52	46.8	100	67	67.0
Total	2 909	1 395	48.0	1 128	453	40.2	923	418	45.3	858	524	61.1

in these two areas were 60% in the coastal against 83.3% in the inland area. However, the difference is not statistically significant. The class of workers with the lowest rates (exclusive of the pre-school children) are for obvious reasons the office workers and the professional group, with an over-all infection rate ranging between 16% and 26%. The rest (students, housekeepers and "jobless" persons) occupy an intermediate position between the first two groups mentioned, with a range of approximately 51% to 58%.

Significant differences in the general prevalence of infection in the three environments exist, with the highest prevalence rate (61.1%) in the inland division. The differences noted are, as one would expect, due to the opportunities for infection and the general sociological make-up of the population. Age distributions of infected individuals in the three environments exhibit other epidemiological features (Fig. 11). In the inland area, transmission takes place more rapidly, with the age prevalence

FIG. 11. AGE PREVALENCE OF SCHISTOSOME INFECTION IN THE THREE DIVISIONS OF PALO, 1953-54



curve rising more steeply and the peak being attained in the age-group 15-19, five years earlier than in the other two areas of Palo. The coastal and the población areas show a concomitant rise, with the maximum prevalence for both in the age-group 20-24. Having reached the peak the infection rate in the coastal area occupies an intermediate position, in respect of general age prevalence, between the población and inland areas. This position is explainable on the basis not only of the environmental but also of the occupational differences referred to above.

The prevalence, therefore, in respect of age, sex, occupation and environment follows a pattern explainable on the basis of opportunities for contact with infection. A factor in respect of age—namely, the downward trend with advancing age after the peak prevalence is reached—could be provisionally explained on the basis of a host reaction, arising from humoral response to infection with a possible immunity mechanism coming into play, or from host-cell reaction around infiltrated eggs tending to wall them off in the intestinal tissues, or from both. We shall return later to a fuller consideration of this subject.

Tanauan

The age distribution of the infection in the control area of Tanauan and its three environmental divisions, based on considerations similar to those in the pilot area of Palo, is given in Table XIX. In a stratified sample of 2246 individuals examined, 46.3% were found infected as compared to 48.0% for Palo, the difference in rates in the two municipalities being made up almost entirely by the difference in the rates among females in the two areas.

Age prevalence rates in Tanauan and in Palo show a general parallelism except that for Tanauan there is a much steeper rise, with the attainment of the peak in an earlier age-group (10-14 years). The downward trend after the peak is reached is repeated as in the case of Palo. This earlier attainment of peak is also noticeable in respect of the inland and the coastal areas in Tanauan. This difference, in spite of the general prevalence rate not being very different in the two municipalities, we are unable to explain as we do not yet know the distribution and extent of snail colonies and infested waters in Tanauan as well as we do for the pilot area in Palo. Reference to Fig. 12 will show that, unlike those for Palo, in Tanauan

FIG. 12. AGE PREVALENCE OF SCHISTOSOME INFECTION IN THE THREE DIVISIONS OF TANAUAN, 1953-54

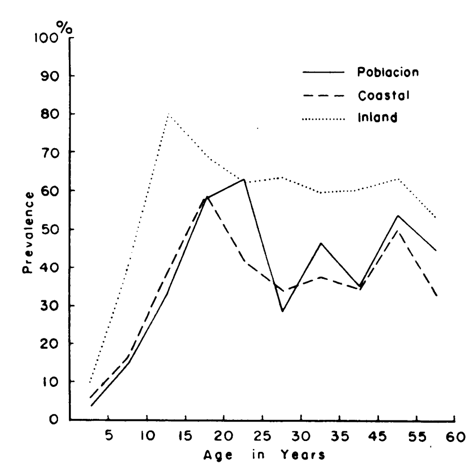


TABLE XIX. AGE PREVALENCE OF SCHISTOSOME INFECTION IN TANAUAN AND ITS THREE DIVISIONS (1953-54)

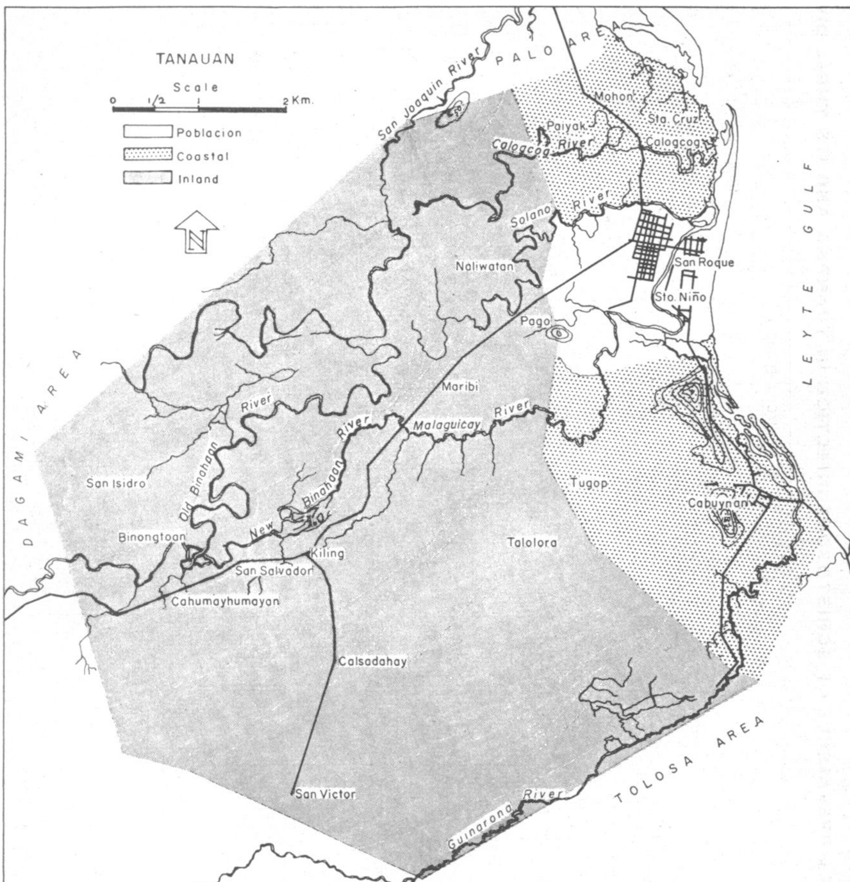
Town and division	Age-group (years)										Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–44	45–54	55 and over	
Tanauan											
Number examined	261	355	284	192	178	169	167	268	169	203	2 246
Number schistosome-positive	20	112	185	125	101	85	85	137	98	91	1 039
Percentage schistosome-positive	7.7	31.5	65.1	65.1	56.7	50.3	50.9	51.1	58.0	44.8	46.3
Población											
Number examined	32	27	27	17	24	14	15	20	13	18	207
Number schistosome-positive	1	4	9	10	15	4	7	7	7	8	72
Percentage schistosome-positive	3.1	14.8	33.3	58.8	62.5	28.6	46.7	35.0	53.8	44.4	34.8
Coastal											
Number examined	76	104	73	61	48	59	56	78	56	73	684
Number schistosome-positive	4	17	28	36	20	20	21	27	28	24	225
Percentage schistosome-positive	5.3	16.3	38.4	59.0	41.7	33.9	37.5	34.6	50.0	32.9	32.9
Inland											
Number examined	153	224	184	114	106	96	96	170	100	112	1 355
Number schistosome-positive	15	91	148	79	66	61	57	103	63	59	742
Percentage schistosome-positive	9.8	40.6	80.4	69.3	62.3	63.5	59.4	60.6	63.0	52.7	54.8

TABLE XX. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN TUANANA AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)												Total	
	below 10		10–19		20–29		30–39		40–49		50 and over			
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
Tanauan														
Number examined	316	300	248	228	170	177	149	161	93	118	143	143	1 119	1 127
Number schistosome-positive	75	57	169	141	91	95	83	72	58	64	76	58	552	487
Percentage schistosome-positive	23.7	19.0	68.1	61.8	53.5	53.7	55.7	44.7	62.4	54.2	53.1	40.6	49.3	43.2
Población														
Number examined	32	27	22	22	20	18	12	15	7	9	13	10	106	101
Number schistosome-positive	3	2	11	8	10	9	7	5	2	5	8	2	41	31
Percentage schistosome-positive	9.4	7.4	50.0	36.4	50.0	50.0	58.3	33.3	28.6	55.6	61.5	20.0	38.7	30.7
Coastal														
Number examined	91	89	69	65	54	53	44	56	25	34	57	47	340	344
Number schistosome-positive	14	7	33	31	21	19	20	14	13	14	26	13	127	98
Percentage schistosome-positive	15.4	7.9	47.8	47.7	38.9	35.8	45.5	25.0	52.0	41.2	45.6	27.7	37.4	28.5
Inland														
Number examined	193	184	157	141	96	106	93	90	61	75	73	86	673	682
Number schistosome-positive	58	48	125	102	60	67	56	53	43	45	42	43	384	358
Percentage schistosome-positive	30.1	26.1	79.6	72.3	62.5	63.2	60.2	58.9	70.5	60.0	57.5	50.0	57.1	52.5

the age prevalence curves for the población and coastal divisions run practically parallel to one another with no significant differences in rates. This is explicable by the geographical location of the población in Tanauan, which is practically coastal (Fig. 13).

FIG. 13. CONTROL AREAS IN TANAUAN, SHOWING ENVIRONMENTAL DIVISIONS



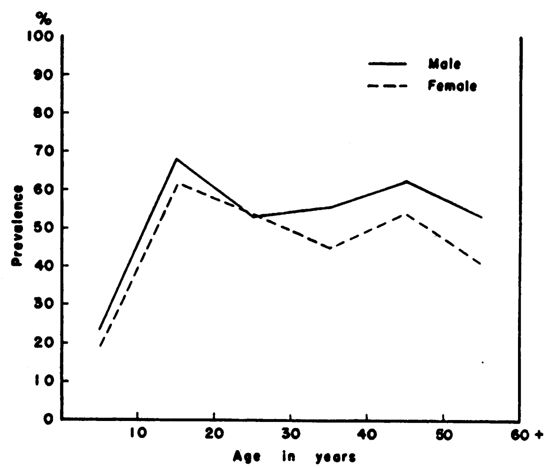
The age and sex distribution of infected individuals is shown in Table XX and Fig. 14. Sex differences are evident, with the prevalence being higher in males than in the females. The over-all rate among males in Tanauan is not different from that in Palo (49.3% and 49.6%, respectively), but the rates among females are 46.4% and 43.2% respectively.

The same reservation applies for Tanauan as for Palo in respect of infection rates and occupational differences. Farmers, tuba-gatherers,

TABLE XXI. PREVALENCE OF SCHISTOSOME INFECTION IN THE DIFFERENT OCCUPATIONAL GROUPS IN TANAUAN AND ITS THREE DIVISIONS (1953-54)

Occupation	Tanauan			Población			Coastal			Inland		
	number examined	number positive	percentage positive	number examined	number positive	percentage positive	number examined	number positive	percentage positive	number examined	number positive	percentage positive
Pre-school	390	54	13.8	47	3	6.4	112	7	6.3	231	44	19.0
Student	445	245	55.1	38	13	34.2	124	44	35.5	283	188	66.4
Housekeeper	591	302	51.1	58	23	39.7	190	71	37.4	343	208	60.6
Farmer	297	185	62.3	3	2	66.7	48	24	50.0	246	159	64.6
Tuba-gatherer	13	8	61.5	1	1	100.0	10	5	50.0	2	2	100.0
Fisherman	114	57	50.0	36	19	52.8	74	36	48.6	4	2	50.0
Unskilled labourer	83	49	59.0	4	3	75.0	30	12	40.0	49	34	69.4
Skilled labourer	99	55	55.6	6	2	33.3	19	8	42.1	74	45	60.8
Shopkeeper	19	7	36.8	2	0	0	10	2	20.0	7	5	71.4
Office worker	2	0	0	0	0	0	1	0	0	1	0	0
Professional	8	2	25.0	1	0	0	3	0	0	4	2	50.0
Jobless	185	75	40.5	11	6	54.5	63	16	25.4	111	53	47.7
Total	2 246	1 039	46.3	207	72	34.8	684	225	32.9	1 355	742	54.8

FIG. 14. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN TANAUAN, 1953-54



and unskilled labourers constitute the group with the highest rates of infection. Fishermen in Tanauan, being predominantly seafaring, have a lower rate than in Palo. The rest conform to the general Palo pattern (Table XXI).

There will thus be seen a great measure of similarity in the disease situation in the pilot and the control areas of Palo and Tanauan.

Carigara

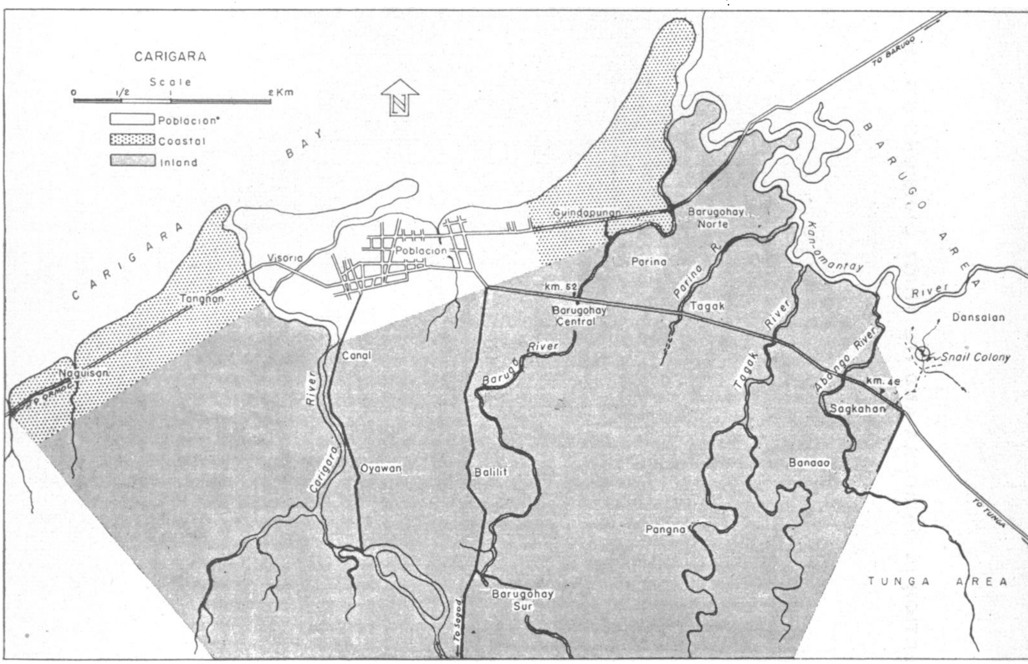
The general layout of this municipality on the northern coast of the endemic valley is shown in Fig. 15, and will be seen somewhat to resemble that of Tanauan. Carigara has also been divided into the población, coastal and inland areas. There appear to be no marked cultural or demographic differences between this and the two preceding towns.

The prevalence of infection in Carigara is presented in Table XXII. Among the 500 individuals examined in the población, no infection was detected. Nine were found infected in the coastal barrios out of a population of 509 examined, giving a prevalence rate of less than 2%. The infected individuals were found in the two widely separated barrios of Barugohay Norte and Nauguisan. In the 11 inland barrios, 35 individuals out of 647 examined were found infected, giving an infection rate of 5.4%. Thirty of the infected individuals were from the three barrios nearest to the only snail colony discovered—that in Dansalan at the eastern edge of the municipality, as indicated on the map. The other cases were found scattered in four other barrios. Infected field rats were found up to one kilometre on either side of the Tagak river, but extensive and painstaking search did not reveal the presence of any snail colony within the municipality

TABLE XXII. AGE PREVALENCE OF SCHISTOSOME INFECTION IN CARIGARA AND ITS THREE DIVISIONS (1954-55)

Town and division	Age-group (years)										Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–44	45–54	55 and over	
Carigara											
Number examined	288	309	240	126	108	106	79	182	119	99	1 656
Number schistosome-positive	0	2	4	4	8	8	2	7	8	1	44
Percentage schistosome-positive	0	0.6	1.7	3.2	7.4	7.5	2.5	3.8	6.7	1.0	2.7
Población											
Number examined	93	96	82	38	21	21	28	70	28	23	500
Number schistosome-positive	0	0	0	0	0	0	0	0	0	0	0
Percentage schistosome-positive	0	0	0	0	0	0	0	0	0	0	0
Coastal											
Number examined	80	90	74	41	45	34	17	52	46	30	509
Number schistosome-positive	0	0	0	1	3	2	0	1	2	0	9
Percentage schistosome-positive	0	0	0	2.4	6.7	5.9	0	1.9	4.3	0	1.8
Inland											
Number examined	115	123	84	47	42	51	34	60	45	46	647
Number schistosome-positive	0	2	4	3	5	6	2	6	6	1	35
Percentage schistosome-positive	0	1.6	4.8	6.4	11.9	11.8	5.9	10.0	13.3	2.2	5.4

FIG. 15. AREA SURVEYED IN CARIGARA, SHOWING ENVIRONMENTAL DIVISIONS



of Carigara proper. However, it should be borne in mind that field rats can travel considerable distances, fording rivers and streams in search of food.

Because of the small number of infected individuals we are unable to draw any valid conclusion as to age, sex or occupational differences from the data presented in Tables XXII-XXIV. It will, however, be noted that of the total of 44 cases, 34 are in persons 20 years old and over, with a marked preponderance of males (24 males to 10 females). We feel doubtful whether they are indigenous cases, but we have not yet ascertained how many of these individuals are imported cases who have moved into Carigara from the neighbouring areas in the endemic valley.

With a low prevalence rate of 2.7% and in view of what has been said above, Carigara could at most be regarded as hypo-endemic, and with due precautions could serve as a check area to obtain answers for clarification of some of the obscure points in the epidemiology of the disease in Palo. To such a possibility we shall refer later.

Bagahupi

Bagahupi is the only known endemic area north of Tacloban, along the newly opened (1954) highway to the municipality of Babatñgon, of

TABLE XXIII. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN CARIGARA AND ITS THREE DIVISIONS (1954-55)

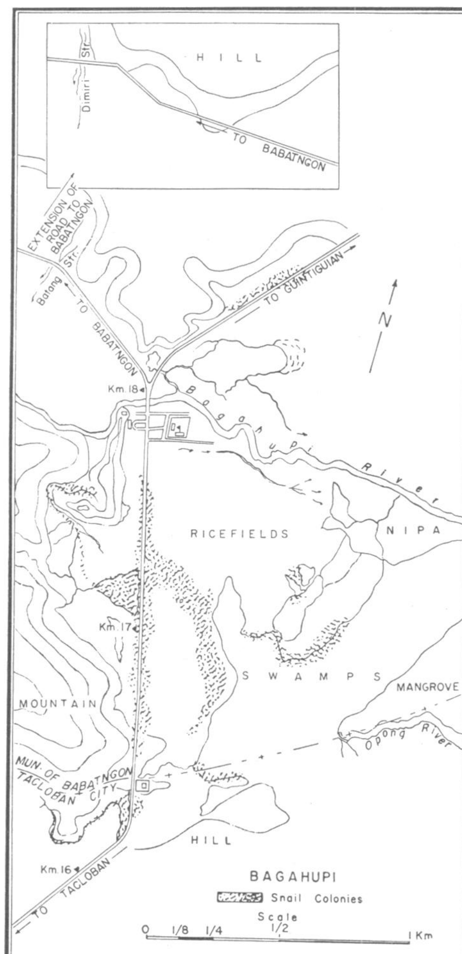
Town and division	Age-group (years)												Total	
	below 10		10–19		20–29		30–39		40–49		50 and over			
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
Carigara														
Number examined	313	284	204	162	103	111	69	94	76	95	80	65	845	811
Number schistosome-positive	1	1	5	3	11	5	3	2	7	2	3	1	30	14
Percentage schistosome-positive	0.3	0.4	2.5	1.9	10.7	4.5	4.3	2.1	9.2	2.1	3.8	1.5	3.6	1.7
Población														
Number examined	98	91	66	54	17	25	20	43	27	29	16	14	244	256
Number schistosome-positive	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percentage schistosome-positive	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coastal														
Number examined	93	77	63	52	41	38	16	17	22	41	28	21	263	246
Number schistosome-positive	0	0	0	1	3	2	0	0	1	0	1	1	5	4
Percentage schistosome-positive	0	0	0	1.9	7.3	5.3	0	0	4.5	0	3.6	4.8	1.9	1.6
Inland														
Number examined	122	116	75	56	45	48	33	34	27	25	36	30	338	309
Number schistosome-positive	1	1	5	2	8	3	3	2	6	2	2	0	25	10
Percentage schistosome-positive	0.8	0.9	6.7	3.6	17.8	6.3	9.1	5.9	22.2	8.0	5.6	0	7.4	3.2

TABLE XXIV. PREVALENCE OF SCHISTOSOME INFECTION IN THE DIFFERENT OCCUPATIONAL GROUPS IN CARIGARA AND ITS THREE DIVISIONS (1954-55)

Occupation	Carigara			Población			Coastal			Inland		
	number examined	number positive	percentage positive	number examined	number positive	percentage positive	number examined	number positive	percentage positive	number examined	number positive	percentage positive
Pre-school	398	1	0.3	135	0	0	112	0	0	151	1	0.7
Student	366	3	0.8	138	0	0	116	0	0	112	3	2.7
Housekeeper	368	12	3.3	106	0	0	117	4	3.4	145	8	5.5
Farmer	140	11	7.9	11	0	0	23	2	8.7	106	9	8.5
Tuba-gatherer	12	2	16.7	0	0	0	2	1	50.0	10	1	10.0
Fisherman	96	2	2.1	24	0	0	70	2	2.9	2	0	0
Unskilled labourer	52	6	11.5	20	0	0	12	0	0	20	6	30.0
Skilled labourer	17	2	11.8	8	0	0	1	0	0	8	2	25.0
Shopkeeper	10	0	0	6	0	0	1	0	0	3	0	0
Office worker	8	0	0	4	0	0	3	0	0	1	0	0
Professional	13	0	0	7	0	0	3	0	0	3	0	0
Jobless	176	5	2.8	41	0	0	49	0	0	86	5	5.8
Total	1 656	44	2.7	500	0	0	509	9	1.8	647	35	5.4

which Bagahupi is a barrio. The lands around the barrio have been recently cleared and one still sees the stumps of hardwood trees in the area. A map of the barrio showing the snail-infested grounds is given in Fig. 16.

FIG. 16. BAGAHUPI, BABATÑGON, SHOWING SNAIL COLONIES



Of the 177 individuals examined in the total population of 822, 76 or nearly 43% were found infected.

The age distribution (Table XXV) shows the maximum prevalence rate of nearly 69% in the age-group 20-24 years. The infection rate is greater among males than among females (see Table XXVI and Fig. 17).

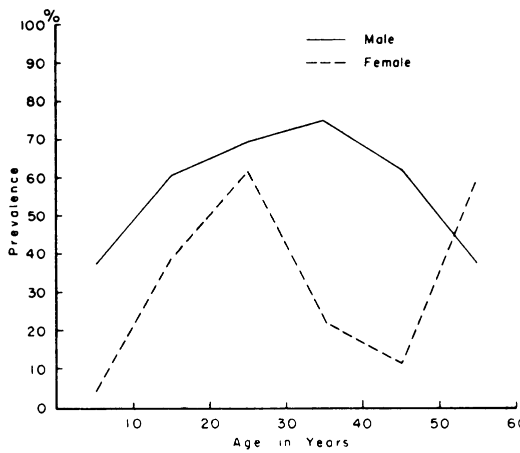
TABLE XXV. AGE PREVALENCE OF SCHISTOSOME INFECTION IN BAGAHUPI (1955)

Age-group (years)	Number examined	Number schistosome-positive	Percentage schistosome-positive
Below 5	21	3	14
5-9	32	10	31
10-14	33	19	58
15-19	18	7	39
20-24	16	11	69
25-29	10	6	60
30-34	7	4	57
35-44	20	8	40
45-54	8	2	50
55 and over	12	6	50
Total	177	76	42.9

TABLE XXVI. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN BAGAHUPI (1955)

Age-group (years)	Sex	Number examined	Number schistosome-positive	Percentage schistosome-positive
Below 10	Male	32	12	38
	Female	21	1	5
10-19	Male	28	17	61
	Female	23	9	39
20-29	Male	13	9	69
	Female	13	8	62
30-39	Male	8	6	75
	Female	9	2	22
40-49	Male	8	5	63
	Female	9	1	11
50 and over	Male	8	3	38
	Female	5	3	60
Total	Male	97	52	54
	Female	80	24	30

FIG. 17. AGE AND SEX PREVALENCE OF SCHISTOSOME INFECTION IN BAGAHUPI, 1955



Farmers, tuba-gatherers and the " jobless " are the occupational groups with a prevalence rate of over 50% (Table XXVII).

TABLE XXVII. PREVALENCE OF SCHISTOSOME INFECTION IN THE DIFFERENT OCCUPATIONAL GROUPS IN BAGAHUPI (1955)

Occupation	Number examined	Number schistosome-positive	Percentage schistosome-positive
Pre-school	32	4	13
Student	37	17	46
Housekeeper	35	14	40
Farmer	29	20	69
Tuba-gatherer	2	1	50
Fisherman	2	0	0
Unskilled labourer	6	2	33
Skilled labourer	3	0	0
Shopkeeper	0	0	0
Office worker	0	0	0
Professional	0	0	0
Jobless	31	18	58
Total	177	76	42.9

Prevalence of Common Helminthic Infections and Relationship to Age, Sex and Environment in Palo

We have drawn attention to the public health importance of the common helminthic infections—*Ascaris*, *Trichuris* and *Ancylostoma*—in our general discussion on health in Leyte Province. Our present study only confirms the previous findings (Pesigan, 1950) that the prevalence of infection with one or more of these three parasites in the four areas surveyed is over 98%—Palo 99.3%, Tanauan 92.2%; Carigara 98.0% and Bagahupi 98.9% (Table XXVIII).

The study of the common intestinal helminths in each of these areas therefore seemed essential to us not only for the clarification of the epidemiology of bilharziasis, obscured in many ways by the high prevalence of these infections, but also because of the fact that one mass disease can play an important role in conditioning the reaction of a host population

TABLE XXVIII. PREVALENCE RATES FOR ONE OR MORE OF THE COMMON HELMINTHIC INFECTIONS IN PALO, TANAUAN, CARIGARA AND BAGAHUPI BY DIVISIONS (1953-55)

Town and divisions	Number examined	Number positive for parasites	Percentage positive for parasites
Palo	2 909	2 889	99.3
Población	1 128	1 124	99.6
Coastal	923	914	99.0
Inland	858	851	99.2
Tanauan	2 246	2 229	99.2
Población	207	206	99.5
Coastal	684	681	99.6
Inland	1 355	1 342	99.0
Carigara	1 656	1 623	98.0
Población	500	489	97.8
Coastal	509	504	99.0
Inland	647	630	97.4
Bagahupi area	177	175	98.9
Bagahupi proper	127	126	99.2
Pagsulhugon	13	13	100.0
Tagpuro	37	36	97.3

to another. Epidemiological methods could be used in evaluating such effects (Gordon & Riche, 1950). We believe that no disease exists wholly by itself. In varying degree each impinges on the other (Emerson, 1942; Gordon, 1953).

We took advantage of the stool surveys for bilharziasis to study in as much detail as practicable the epidemiological features of these three infections. We have presented data here in respect of the pilot area in Palo and reference to other areas surveyed will be made at a later stage, but it may be mentioned here that the over-all picture of these infections is very similar in all the areas.

The data presented here for Palo are in a large measure a by-product of our first study, on the prevalence of bilharziasis, and, owing to our pre-occupation with that study, quantitative determination of eggs to establish intensity, or worm burden, was limited to the detailed studies in connexion with the measurement of disease presented in the next section.

The age distribution of the three helminthic infections is shown in Tables XXIX, XXXI, XXXIII, and Fig. 18. *Ascaris* infection attains an early peak of over 90% in all the three environments in the age-group 5-9 years. *Trichuris* follows suit with an almost equal rate of infection.

FIG. 18. AGE PREVALENCE OF INTESTINAL HELMINTHS IN PALO AND ITS THREE DIVISIONS, 1953-54

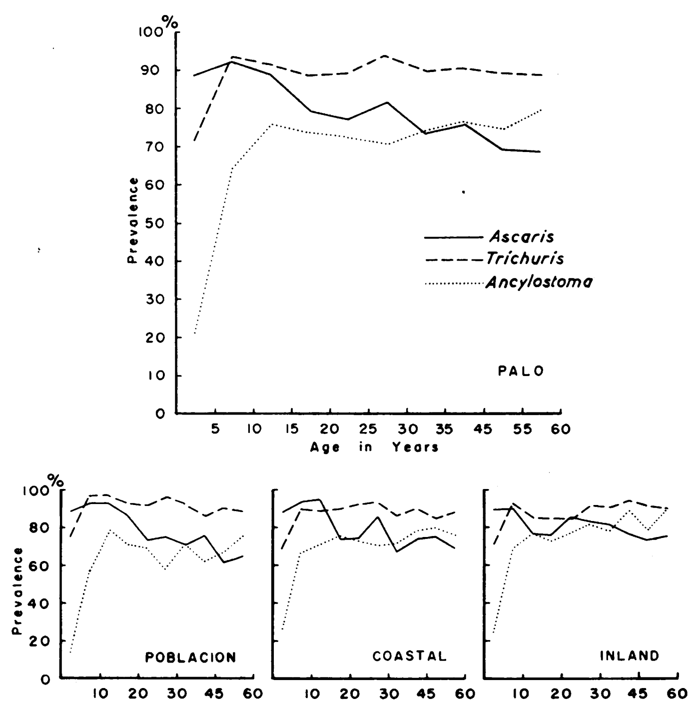


TABLE XXIX. AGE PREVALENCE OF *ASCARIS* INFECTION IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and divisions	Age-group (years)										Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–44	45–54	55 and over	
Palo											
Number examined	386	455	384	302	218	207	186	323	253	195	2 909
Number *Ascaris*-positive	341	420	340	241	168	168	136	244	174	133	2 365
Percentage *Ascaris*-positive	88.3	92.3	88.5	79.8	77.1	81.2	73.1	75.5	68.8	68.2	81.3
Población											
Number examined	138	159	136	138	86	82	73	115	113	88	1 128
Number *Ascaris*-positive	121	148	127	118	63	62	52	87	70	57	905
Percentage *Ascaris*-positive	87.7	93.1	93.4	85.5	73.3	75.6	71.2	75.7	61.9	64.8	80.2
Coastal											
Number examined	131	143	122	88	76	57	58	108	73	67	923
Number *Ascaris*-positive	115	134	116	65	57	49	39	80	55	46	756
Percentage *Ascaris*-positive	87.8	93.7	95.1	73.9	75.0	86.0	67.2	74.1	75.3	68.7	81.9
Inland											
Number examined	117	153	126	76	56	68	55	100	67	40	858
Number *Ascaris*-positive	105	138	97	58	48	57	45	77	49	30	704
Percentage *Ascaris*-positive	89.7	90.2	77.0	76.3	85.7	83.8	81.8	77.0	73.1	75.0	82.1

TABLE XXX. PREVALENCE OF *ASCARIS* INFECTION BY AGE AND SEX IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)												Total	
	below 10		10–19		20–29		30–39		40–49		50 and over			
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
Palo														
Number examined	439	402	331	355	195	230	155	199	138	146	138	181	1 396	1 513
Number *Ascaris*-positive	396	365	287	294	145	191	109	155	92	111	94	126	1 123	1 242
Percentage *Ascaris*-positive	90.2	90.8	86.7	82.8	74.4	83.0	70.3	77.9	66.7	76.0	68.1	69.6	80.4	82.1
Población														
Number examined	145	152	135	139	73	95	61	72	49	66	65	76	528	600
Number *Ascaris*-positive	130	139	125	120	50	75	41	55	32	45	42	51	420	485
Percentage *Ascaris*-positive	89.7	91.4	92.6	86.3	68.5	78.9	67.2	76.4	65.3	68.2	64.6	67.1	79.5	80.8
Coastal														
Number examined	147	127	97	113	64	69	46	64	48	46	43	59	445	478
Number *Ascaris*-positive	134	115	83	98	48	58	30	48	32	39	29	43	356	400
Percentage *Ascaris*-positive	91.2	90.6	85.6	86.7	75.0	84.1	65.2	75.0	66.7	84.8	67.4	71.2	80.0	83.7
Inland														
Number examined	147	123	99	103	58	66	48	63	41	34	30	46	423	435
Number *Ascaris*-positive	132	111	79	76	47	58	38	52	28	27	23	33	347	357
Percentage *Ascaris*-positive	89.8	90.2	79.8	73.8	81.0	87.9	79.2	82.5	68.3	79.4	76.7	71.7	82.0	82.1

TABLE XXXI. AGE PREVALENCE OF *TRICHURIS* INFECTION IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)										Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–44	45–54	55 and over	
Palo											
Number examined	386	455	384	302	218	207	186	323	253	195	2 909
Number *Trichuris*-positive	276	425	349	268	194	193	167	291	225	173	2 561
Percentage *Trichuris*-positive	71.5	93.4	90.9	88.7	89.0	93.2	89.8	90.1	88.9	88.7	88.0
Población											
Number examined	138	159	136	138	86	82	73	115	113	88	1 128
Number *Trichuris*-positive	103	154	132	125	77	79	67	99	102	78	1 016
Percentage *Trichuris*-positive	74.6	96.9	97.1	90.6	89.5	96.3	91.8	86.1	90.3	88.6	90.1
Coastal											
Number examined	131	143	122	88	76	57	58	108	73	67	923
Number *Trichuris*-positive	90	129	109	79	70	53	50	98	62	59	799
Percentage *Trichuris*-positive	68.7	90.2	89.3	89.8	92.1	93.0	86.2	90.7	84.9	88.1	86.6
Inland											
Number examined	117	153	126	76	56	68	55	100	67	40	858
Number *Trichuris*-positive	83	142	108	64	47	61	50	94	61	36	746
Percentage *Trichuris*-positive	70.9	92.8	85.7	84.2	83.9	89.7	90.9	94.0	91.0	90.0	86.9

TABLE XXXII. PREVALENCE OF *TRICHURIS* INFECTION BY AGE AND SEX IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)												Total	
	below 10		10–19		20–29		30–39		40–49		50 and over			
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
Palo														
Number examined	439	402	331	355	195	230	155	199	138	146	131	181	1 396	1 513
Number *Trichuris*-positive	359	342	303	314	176	211	140	178	129	131	113	165	1 220	1 341
Percentage *Trichuris*-positive	81.8	85.1	91.5	88.5	90.3	91.7	90.3	89.4	93.5	89.7	81.9	91.2	87.4	88.6
Población														
Number examined	145	152	135	139	73	95	61	72	49	66	65	76	528	600
Number *Trichuris*-positive	123	134	128	129	68	88	56	63	46	56	52	73	473	543
Percentage *Trichuris*-positive	84.8	88.2	94.8	92.8	93.2	92.6	91.8	87.5	93.9	84.8	80.0	96.1	89.6	90.5
Coastal														
Number examined	147	127	97	113	64	69	46	64	48	46	43	59	445	478
Number *Trichuris*-positive	114	105	86	102	60	63	39	57	44	43	34	52	377	422
Percentage *Trichuris*-positive	77.6	82.7	88.7	90.3	93.8	91.3	84.8	89.1	91.7	93.5	79.1	88.1	84.7	88.3
Inland														
Number examined	147	123	99	103	58	66	48	63	41	34	30	46	423	435
Number *Trichuris*-positive	122	103	89	83	48	60	45	58	39	32	27	40	370	376
Percentage *Trichuris*-positive	83.0	83.7	89.9	80.6	82.8	90.9	93.8	92.1	95.1	94.1	90.0	87.0	87.5	86.4

TABLE XXXIII. AGE PREVALENCE OF *ANCYLOSTOMA* INFECTION IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)										Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–44	45–54	55 and over	
Palo											
Number examined	386	455	384	302	218	207	186	323	253	195	2 909
Number *Ancylostoma*-positive	84	293	292	221	158	145	137	246	188	154	1 918
Percentage *Ancylostoma*-positive	21.8	64.4	76.0	73.2	72.5	70.0	73.7	76.2	74.3	79.0	65.9
Población											
Number examined	138	159	136	138	86	82	73	115	113	88	1 128
Number *Ancylostoma*-positive	19	90	108	98	59	48	52	72	76	67	689
Percentage *Ancylostoma*-positive	13.8	56.6	79.4	71.0	68.6	58.5	71.2	62.6	67.3	76.1	61.1
Coastal											
Number examined	131	143	122	88	76	57	58	108	73	67	923
Number *Ancylostoma*-positive	35	96	87	67	56	41	42	85	59	51	619
Percentage *Ancylostoma*-positive	26.7	67.1	71.3	76.1	73.7	71.9	72.4	78.7	80.8	76.1	67.1
Inland											
Number examined	117	153	126	76	56	68	55	100	67	40	858
Number *Ancylostoma*-positive	30	107	97	56	43	56	43	89	53	36	610
Percentage *Ancylostoma*-positive	25.6	69.9	77.0	73.7	76.8	82.4	78.2	89.0	79.1	90.0	71.1

TABLE XXXIV. PREVALENCE OF *ANCYLOSTOMA* INFECTION BY AGE AND SEX IN PALO AND ITS THREE DIVISIONS (1953-54)

Town and division	Age-group (years)												Total	
	below 10		10–19		20–29		30–39		40–49		50 and over			
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
Palo														
Number examined	439	402	331	355	195	230	155	199	138	146	138	181	1 396	1 513
Number *Ancylostoma*-positive	220	157	268	245	159	144	131	135	114	97	116	132	1 008	910
Percentage *Ancylostoma*-positive	50.1	39.1	81.0	69.0	81.5	62.6	84.5	67.8	82.6	66.4	84.1	72.9	72.2	60.1
Población														
Number examined	145	152	135	139	73	95	61	72	49	66	65	76	528	600
Number *Ancylostoma*-positive	62	47	115	91	57	50	47	42	33	40	52	53	366	323
Percentage *Ancylostoma*-positive	42.8	30.9	85.2	65.5	78.1	52.6	77.0	58.3	67.3	60.6	80.0	69.7	69.3	53.8
Coastal														
Number examined	147	127	97	113	64	69	46	64	48	46	43	59	445	478
Number *Ancylostoma*-positive	78	53	73	81	51	46	41	43	44	29	36	44	323	296
Percentage *Ancylostoma*-positive	53.1	41.7	75.3	71.7	79.7	66.7	89.1	67.2	91.7	63.0	83.7	74.6	72.6	61.9
Inland														
Number examined	147	123	99	103	58	66	48	63	41	34	30	46	423	435
Number *Ancylostoma*-positive	80	57	80	73	51	48	43	50	37	28	28	35	319	291
Percentage *Ancylostoma*-positive	54.4	46.3	80.8	70.9	87.9	72.7	89.6	79.4	90.2	82.4	93.3	76.1	75.4	66.9

Ancylostoma infection, rising sharply to attain a prevalence of about 70% in the age-group 10-15 years, continues to build up slowly throughout adult life. In young children, *Ascaris* and *Trichuris*, being in effect hand-to-mouth and "door-yard" infections, are naturally acquired very early. While the *Ascaris* infection shows a definite downward trend with increasing age, *Trichuris* shows no such fall, its prevalence remaining practically constant throughout life. This stability of *Trichuris* infection may be explained on the basis of the greater longevity of the parasite, its mode of attachment to the intestinal mucosa and the possible lack of development of any host resistance to the parasite.

No sex differences exist in respect of *Ascaris* and *Trichuris* (Tables XXX, XXXII). Males show a significantly higher rate of *Ancylostoma* infection than females throughout the different age-groups. *Ancylostoma* infection is acquired farther from the immediate vicinity of the house and the mates, being more active, run a greater risk of acquiring the infection than do females generally (Table XXXIV).

The prevalence by divisions of the survey areas for the three helminths may also be seen from the tables. The prevalence of *Ascaris* (Table XXIX) and *Trichuris* (Table XXXI) is very high (81.3% and 88.0% respectively) and shows little variations between the different environments. *Ancylostoma* infection exhibits environmental differences but not to any marked degree —población 61.1%, coastal division 67.1% and inland division 71.1%. There would seem to be a combination of at least two factors that could influence the noted differences—namely, sanitation and the nature of the soil, to which detailed reference has already been made. It is difficult to differentiate the relative effects of the two factors (partial sanitation and nature of soil) in this case except by a controlled experiment. However, the fact remains that the marked differences in sanitary conditions in the three divisions seem to have produced no effect on the two first-named parasites, while the impression made on the third (*Ancylostoma*) in the población by 65% of the houses having latrines and by cleaner yards seems to be small. While there can be no doubt of the value of proper sanitation on helminthic infection, we are inclined to the view that partial or focal sanitation, as in the población, wedged between two other divisions of the town with poor sanitation, does not seem to be of much avail. This observation is in conformity with the findings reported by Chernin in 1954 of a survey of intestinal parasites conducted among workers at a jute mill near Calcutta, India. The inevitable conclusion of that study was that pin-point sanitation cannot by itself be effective in the face of an environment in which sanitation in general is of a low order. A similar investigation of intestinal parasitism in the Philippines was conducted by Lara and associates in 1953 among workers of a sugar mill in the province of Negros Occidental. Of the nine barrios surveyed, six were provided with company-built community latrines and bath-houses.

The survey showed that while intestinal parasitism was a problem in the population of all barrios studied, the problem was greatest in six barrios, three with and three without latrines.

We have also taken note of two more recent studies from other parts of the world,—one reported by Sanches & Wagner (1954) from Brazil and the other by Chandler (1954) from Egypt.

As part of a programme for rural sanitation in Brazil, 18 000 privies were constructed in a project in the Amazon valley and intensive treatment for " worm infestation " was carried out at the same time. Surveys made before and 3-4 years afterwards showed that the prevalence of hookworm fell in all localities from 37.6% to 25.4%, and the intensity of infection also decreased. However, the results were not as good as were expected, and the authors reached the conclusion that privy projects alone are not the final answer to the excreta disposal problem in the rural areas.

In the Egyptian study, one of a group of four villages that had bored-hole latrines installed in the majority of the houses, an unpolluted water supply for the entire population, and health services developed two years previously through the co-operative efforts of the International Health Division of the Rockefeller Foundation and the Egyptian Ministry of Public Health was compared for helminthic infections with a control village which did not enjoy these benefits. Resurvey after two years showed a marked difference in the two villages as far as helminthic infection rates and the intensity of infections were concerned. The conclusion was drawn that with sanitation applied to a wider area as part of an over-all public health programme, one would expect the helminthic infection rates to be lowered to the point where the infestations cease to be a public health problem.

We have quoted the above instances in support of our explanation of the small difference, or lack of difference, in the prevalence of intestinal helminths in the three different environments of Palo, but it is not meant to imply that adequate sanitation, however limited in scope, should not be encouraged. The aim, even in small communities, is initially to equip the families with the necessary facilities to learn a new habit of life, but one should not expect any immediate benefit in the form of a fall in prevalence or intensity of intestinal infections unless such a programme is planned on a larger scale as part of a total public health and community development project directed at raising the living standards of the people in the rural areas.

Natural History and Public Health Significance of Bilharziasis

The natural history of bilharziasis is only partially known. Well-studied series of clinical cases are readily found, but we have not come across any study in which cases have been followed up in a community over a period of time to determine progress or prognosis of the disease in relation either to the characteristics of the persons attacked or to the environment in which the disease arises. Recently there has been a trend towards a long-term, prospective type of epidemiological approach (longitudinal studies) in respect of chronic diseases. Such studies shed more light on the natural history of diseases, much of which is lost in short-term cross-sectional surveys, and generalizations regarding the public health significance of the disease based on the latter type of survey may be misleading. Long-term studies are naturally time-consuming, but much more satisfying and rewarding (Sartwell, 1944; Dyar, 1953; Moore, 1953; Lew & Marks, 1955; Dunn, 1956).

The two field studies reported in this section have been planned on the basis of half-yearly examinations of the individuals in the samples, at least for the duration of this project and possibly longer.

Apart from obtaining fuller knowledge of the natural history of the disease and seeking clues and clarification of obscure points in the epidemiology of the disease in this area, we hope to be able to answer certain specific questions that have been raised.

The WHO Expert Committee on Bilharziasis (1953) while dealing with the subject of the social significance of the disease, made the following statement:

> " Infection with *Schistosoma* is often well tolerated and without clinical signs. However, this relative benignity appears to vary considerably from country to country without the cause of these variations being as yet thoroughly understood."

The committee therefore pointed out that one of the points which a survey should endeavour to establish is the proportion of clinical cases and serious complications to the number of persons infected, the ratio " disease incidence to infection incidence " being a very important element in assessing the social or the public health significance of bilharziasis. We have taken up this question as a part of the general epidemiological investigation and the method of approach used will, we hope, yield the information sought, enabling us in due course to obtain a quantitative assessment of the resulting incapacity and of the financial burden imposed by the disease.

An approach to quantitative assessment of disease and disability

Death, disease and disability constitute the major criteria of ill health. Cause of death statistics, however, become meaningless in this area, where 95.5% of deaths occur without medical attendance. It is no wonder, therefore, that in the year 1953 the reported number of deaths in the Philippines due to bilharziasis was 109, including 51 in Leyte,[a] and 171 in

[a] According to an assessment made for the WHO Regional Office for the Western Pacific by Dr M. Pascua

1954 (International Co-operation Administration, 1955). Autopsies, except in medico-legal cases, cannot be performed. For the duration of this project, therefore, we have to rule out any possibility of obtaining reliable data on mortality due to bilharziasis that we could use as a measure of its public health significance.

We have no alternative but to resort to the measurement of morbidity as a possible method of approach in answering the question raised. This immediately brings up the subject of diagnosis and classification of the disease, which is a prerequisite for a study of any disease process (Sartwell, 1953). Classification is not easy whatever the disease under study. No all-purpose classification of any disease has been possible. Bilharziasis japonica has been classified on the basis of the three main characteristics— stage, speed and severity—by which the progress of the disease can be distinguished. Faust & Meleney (1924) divided the disease process into three stages, based on the pathology of disease: (1) the stage of invasion and maturation of the parasite; (2) the stage of egg deposition and extrusion; (3) the stage of tissue proliferation and repair. This is the same as early, intermediate and advanced stages of the disease; though it is a logical classification to follow, is not suitable for adoption as a measure of morbidity in our sample, which is already in the " egg extrusion " or the intermediate stage, leaving us with a choice of classification into two later stages without an easy field method of distinguishing where one ends and the other begins. In relation to speed, the disease process may manifest itself as an acute, subacute or chronic process. Faust et al. (1946) have distinguished fulminating, acute, early chronic and late chronic disease. Both the speed and the pathological stages are elements in this concept, but the last two stages could vary markedly in severity, and therefore would not serve as a measure of disability or incapacity, which it is our aim to establish. We have therefore chosen severity of disease as our main criterion, irrespective of the stage or the speed of the disease process and have adopted as simple a classification as possible, dividing it into, mild, moderate, severe and very severe forms, utilizing signs and symptoms attributable to bilharziasis which the patient could easily distinguish and which could be recorded during the course of a short interview. As little disturbance to the patient as possible was considered necessary to ensure his continued co-operation over the series of interviews and examinations proposed. In the following classification of severity, " incapacity " has been included as an important element:

I. *Mild:* occasional abdominal pain, occasional diarrhoea of dysentery; no absence from work.

II. *Moderate:* I, with anaemia (Hb less than 10 g per 100 ml using Haden-Hausser haemoglobinometer) or weakness; inability to do hard work.

III. *Severe:* II, with recurring attacks of diarrhoea and dysentery; frequent absence from work.

IV. *Very severe:* III, with ascites and/or emaciation; total absence from work.

Some explanation seems essential here for not including hepatomegaly as an essential component of any classification of bilharziasis japonica, as the liver is the visceral organ which bears the brunt of the disease in man. It is possible that liver enlargement could be used as an index of measurement of the disease in an area where no other cause for hepatomegaly exists, but hepatomegaly *per se* cannot be used as a measure of disease load unless such enlargement is associated with hepatic insufficiency or hepato-cellular failure (Sherlock, 1955), as extensive liver enlargement is compatible with normal physiological functions of that organ.

Determination of hepatic insufficiency in any way other than noting clinical features was not conceivable in our field studies, which are meant to be repeated every six months on a fairly large and constant sample of 278 individuals of all ages in the community. Liver enlargement in this area is very common even in the absence of bilharziasis, as we shall see in another study reported in this section, and we did not wish to complicate our classification by introducing this factor into it but decided to record liver enlargement in every case separately in some detail.

On the basis of the above classification we have proceeded to establish a disease range in our sample. This is sometimes referred to as the spectrum of clinical severity, but since conditions in nature represent anything but the static situation implied by the word " spectrum ", Gordon (1950) calls it the " biological gradient of disease ". We have used a somewhat simpler term, " clinical gradient ", to express the morbid process from its simplest manifestation to its severest form.

In an individual the disease may progress with the passage of time all the way from the subclinical level to the very severe form, or it may never go beyond some point part-way along on the scale and may then regress. Several factors may operate in determining this process and it is the aim of this study, among other things, to identify such factors as may influence the course of the disease with a view to the possible application of this knowledge to prevention.

Materials and methods

A preliminary pilot study was conducted in a small zone of Palo-Kanbanwa—where careful records of interviews and examination of known infected individuals were made. This enabled us to evolve a standard form for recording data, and to determine the size of the sample for this study. A 20% sample of all stool-positive cases, using 1953-54 survey records from each zone, was drawn by reference to a table of random numbers. Table XXXV shows the number of stool-positive individuals and the size of sample taken from each zone and Table XXXVI the age distribution of the sample. Area distribution was as important to us as the age, because of the possible environmental influences on the character and course of the disease.

Two of us throughout this study visited the individuals in their own

TABLE XXXV. SIZE OF SAMPLE EXAMINED BY ZONES IN PALO

Area	Number stool-positive	Number in sample
Palo (total)	1 395	278
Población	453	91
Buri	98	20
Cavite	85	17
Guindapunan	118	24
Luntad	63	12
Santa Cruz	89	18
Coastal	418	83
Baras-Candahug	114	22
Cogon	159	32
Pawing-Campitic	68	14
San Joaquín	77	15
Inland	524	104
Gacao	143	28
Kanbanwa-Binangkawan (Dazo)	23	5
Malirong	230	46
Purisima-Caloogan	66	13
Takurañga	62	12

houses and interviewed on an average 3-4 individuals in an afternoon (1.30-3.30 p.m.), recording carefully past and present history and findings of physical examinations; haemoglobin was determined and a stool box left for collection next morning for quantitative determination of eggs of schistosomes and other helminths. The first round of examination of 278 individuals was completed during the period December 1954 to August 1955—longer than we had planned, as more than one visit had often to be made to find individuals at home. With rare exceptions, the co-operation obtained was excellent.

The method of recording hepatomegaly and the indices used need fuller explanation here, as at present no recognized method is available which we could adopt.[a]

[a] Since the submission of this manuscript for publication, we have seen H. A. P. C. Oomen's paper on " The relationship between liver size, malaria and diet in Papuan children " (*Docum. Med. geogr. trop. (Amst.)*, 1957, 9, 84), in which he describes his method of assessing liver enlargement in at least two planes. A manuscript copy of his paper on " Nutrition and the Papuan child: a study in human welfare " also became available to us at the fourth meeting of the Nutrition Committee for South and East Asia, sponsored by FAO and WHO and held at Tokyo in September-October 1956; in this paper Oomen describes the method employed by him in measuring liver size in field surveys of Papuan children.—T. P. P. and colleagues, 21 February 1958

TABLE XXXVI. AGE DISTRIBUTION OF THE PALO SAMPLE

Area	Age-group (years)													Total
	below 5	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60 and over	
Palo (total)	1	23	49	38	23	28	15	22	19	20	14	8	18	278
Población	1	6	11	14	13	8	4	6	4	7	6	4	7	91
Coastal	0	5	14	11	8	8	5	10	8	3	4	1	6	83
Inland	0	12	24	13	2	12	6	6	7	10	4	3	5	104

TABLE XXXVII. CLINICAL GRADIENT OF RANDOM SAMPLE OF 278 SCHISTOSOME-INFECTED INDIVIDUALS EXAMINED IN PALO, DIVIDED INTO ITS THREE DIVISIONS (DECEMBER 1954 — AUGUST 1955)

Town and divisions	Number examined	Asymptomatic		Symptomatic		Mild *		Moderate *		Severe *		Very severe *	
		number	%	number	%	number	%	number	%	number	%	number	%
Palo (total)	278	173	62.2	105	37.8	60	57.1	41	39.0	4	3.8	0	0
Población	91	67	74	24	26	12	50	12	50	0	0	0	0
Coastal	83	46	55	37	45	31	84	6	16	0	0	0	0
Inland	104	60	58	44	42	17	39	23	52	4	9	0	0

* Classification of severity:

I. Mild: occasional abdominal pain, occasional diarrhoea or dysentery; no absence from work.

II. Moderate: I, with anaemia (Hb less than 10 g per 100 ml, using Haden-Hausser haemoglobinometer) or weakness; inability to do hard work.

III. Severe: II, with recurring attacks of diarrhoea and dysentery; frequent absence from work.

IV Very severe. III, with ascites, and/or emaciation; total absence from work.

" Finger-breadths " measurements between costal margin and lower border of liver have been used to express liver enlargement. Such measurements are obviously influenced by age, height, the shape of the chest wall of the individual and the thickness of the fingers of the examiner, and therefore cannot be used with acceptable accuracy. Gabaldon in 1933 described a method in which reference is made to fixed points of the body by means of a series of ten parallels and meridians. The average of measurements, right and left latitudes and longitudes, gave the hepatic formula of the whole. Bang et al. (1946) graded the degree of enlargement into 3 classes: a No. 1 liver was regarded as one palpable only in the mid-line and definitely felt upon respiration; a No. 2 liver was clearly palpable without respiration, but did not extend lower than halfway from the xiphoid cartilage to the umbilicus; if it extended beyond this point or was palpable without respiration below the costal margin far to the right, it was called No. 3. The first method may be valuable in following variations in size of liver for clinical work, but is much too elaborate for epidemiological field studies involving large population samples. The second did not provide a sufficient number of gradations and took into consideration only vertical and not lateral enlargement.

By a method of trial and error in the field, we chose a method of classifying liver size which allows of six gradations between the costal margin and the umbilicus and measures enlargements in both the vertical and the lateral direction. This method we find to be simple in practice.

The abdominal wall is divided by four horizontal planes and one vertical plane into ten segments, as shown in Fig. 19.

The three lower horizontal planes correspond to those in Hackett's (1937) classification for splenic enlargement in malariometry; an additional

FIG. 19. DIVISION OF ABDOMINAL WALL INTO TEN SEGMENTS

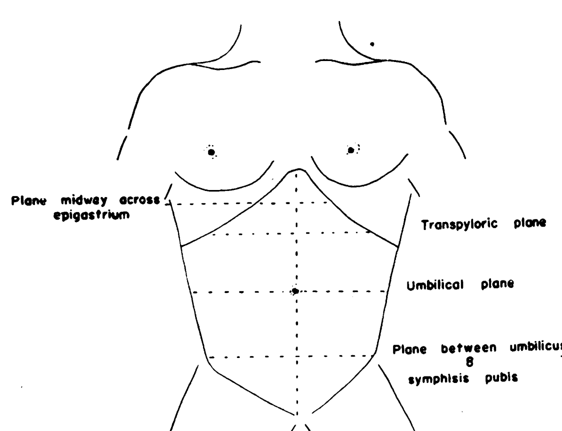
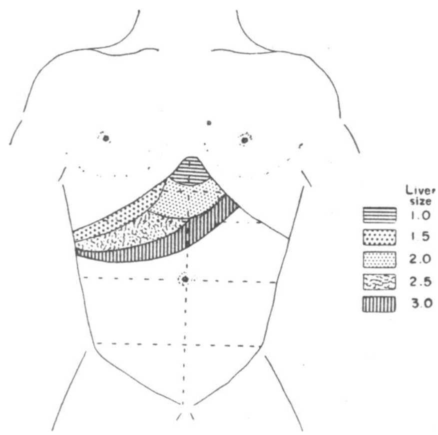


FIG. 20. LOWER BORDER OF LIVER AND CLASSIFICATION OF LIVER SIZE



line is drawn halfway between the lower end of the sternum and the transpyloric plane, dividing the epigastrium into two halves. A median vertical line divides the five segments thus formed into right and left halves.

Liver projecting in one segment is computed as liver size 0.5. If it projects in two segments it is liver size 1 (L1); three segments L 1.5; four segments L 2, and so on up to L 5, giving in all 10 sizes, six of them between the costal margin and the umbilicus.

For illustration, the liver enlargements most commonly encountered in our study and their classification are indicated in Fig. 20. It may be pointed out here that in our studies liver sizes varied from L 0.5 to L 3 and livers projecting below the umbilical plane, i.e., sizes exceeding L 3, have not been found.

The two indices that we have used are:

1. *Liver rate*, expressed as a percentage of livers palpable below the costal margin in the population surveyed.

2. *Average palpable liver* (APL), used as an index of liver size. The total of individuals in each liver-size group is multiplied by the arbitrary class number 0.5 to 5 and the sum of the products is divided by the total of the individuals with palpable livers. This corresponds to the index AES (average enlarged spleen) used in splenic surveys.

The word " enlarged " has been advisedly replaced by " palpable " in recording liver size. All measurements are noted with the patient recumbent and the lower border determined during normal inspiration.

Hackett's (1937) classification is followed in recording splenic enlargements in advanced cases of bilharziasis and the two corresponding indices used are the spleen rate and the AES.

Results

Clinical gradient. The data presented in Table XXXVII express the clinical gradient of the disease in Palo.

The prevalence rate and the clinical fractions of schistosome-infected cases, with percentages representing proportions of the total population in Palo, are given below.

Palo

- Infected (278) 48%
  - Symptomatic (105) 18%
    - Mild (60) 10.3%
    - Moderate (41) 7%
    - Severe (4) 0.7%
    - Very severe (0)
  - Asymptomatic (173) 30%
- Not infected * 52%

* On the basis of single stool examination by the " standard method ", described above in the section on techniques employed.

On the basis of the above classification it will be noted that there is a higher proportion of the less severe forms and a low proportion of the more severe grades of bilharziasis in Palo.

In terms of absolute numbers in the total population in Palo, this could be expressed as:

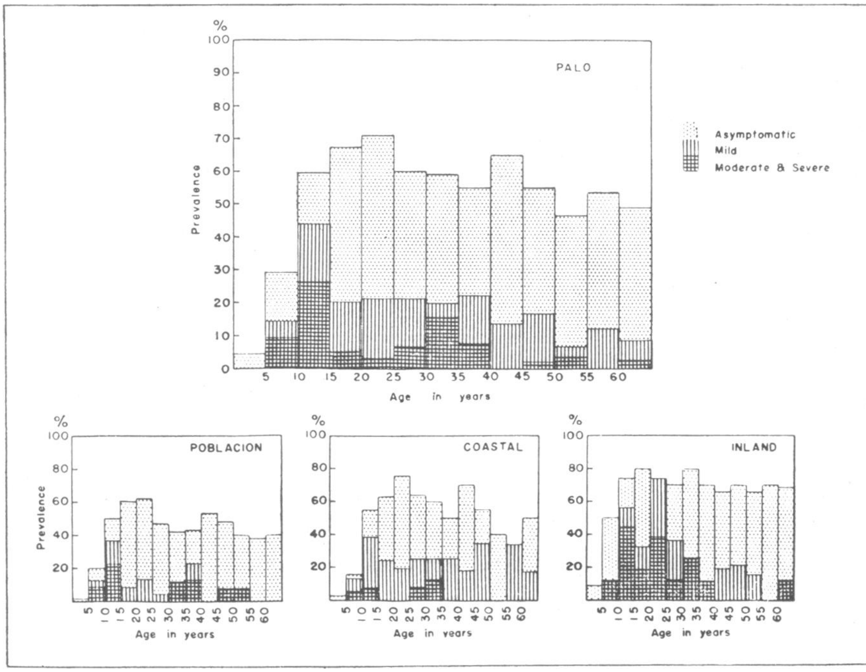
Palo 14 819

- Infected (48%) 7113
  - Symptomatic (18%) 2667
    - Mild (10.3%) 1526
    - Moderate (7%) 1037
    - Severe (0.7%) 104
    - Very severe (0%) 0 **
  - Asymptomatic (30%) 4446
- Not infected (52%) * 7706

* On the basis of single stool examination by the " standard method ", described above in the section on techniques employed.

** Less than 77 according to the 95% confidence limit of the Poisson distribution.

FIG. 21. CLINICAL GRADIENT OF SCHISTOSOME-INFECTED INDIVIDUALS IN PALO AND ITS THREE DIVISIONS



The gradient in Fig. 21 is based on Table XXXVIII and expresses quantitatively the clinical fractions of the disease in the different age-groups in Palo and its three environmental divisions.

Although the prevalence of infection reaches its peak in the age-group 20-24 years, manifest disease and its severe forms dominate the picture during childhood. This is especially true of the age-group 10-14, in which period 73% of the infected children manifest symptoms referable to bilharziasis and among them the majority of cases with moderate to severe symptoms are found. The clinical picture changes thereafter and manifest disease and its severity decline considerably, there being no significant differences in either respect among the different age-groups above 14 years. A similar epidemiological feature for bilharziasis japonica was observed by Fujinami (1916) among the rice farmers in the endemic areas of Japan. Vogel & Minning (1953) report that they made a similar observation in Chekiang Province, China, in 1934, and that Tang and co-workers did likewise in 1950-51 in the Chinese Province of Fukien.

The relationship of sex to the clinical gradient is presented in Table XXXIX. Neither the proportion of asymptomatic cases nor the severity of symptoms shows significant sex differences.

TABLE XXXVIII. CLINICAL GRADIENT OF A RANDOM SAMPLE OF 278 SCHISTOSOME-INFECTED INDIVIDUALS ARRANGED ACCORDING TO AGE DISTRIBUTION IN PALO (DECEMBER 1954—AUGUST 1955)

Age-group years	Number examined	Symptomatic		Mild		Moderate		Severe		Very severe
		number	%	number	%	number	%	number	%	
Below 5	1	0	0	0	0	0	0	0	0	
5–9	23	11	48	4	36	7	64	0	0	
10–14	49	36	73	15	42	18	50	3	8	
15–19	38	11	29	8	73	2	18	1	9	
20–24	23	7	30	6	86	1	14	0	0	
25–29	28	10	36	7	70	3	30	0	0	
30–34	15	5	33	1	20	4	80	0	0	nil
35–39	22	9	41	6	67	3	33	0	0	
40–44	19	4	21	4	100	0	0	0	0	
45–49	20	6	30	5	83	1	17	0	0	
50–54	14	2	14	1	50	1	50	0	0	
55–59	8	1	13	1	100	0	0	0	0	
60 and over	18	3	17	2	67	1	33	0	0	
Total	278	105	38	60	57	41	39	4	4	

In relation to the environmental divisions, it is interesting to note that there is a preponderance of the milder type of disease (84%) in the coastal area, whereas moderate and severe forms of the disease constitute 61% of the clinical cases in the inland division, the proportion of mild and moderate forms being equal in the población. There are no severe cases in either the población or the coastal divisions, nor have very severe forms of the disease, with ascites, emaciation or both, been encountered anywhere in the whole sample.

Any shift in the clinical gradient in relation to age or environment, qualitatively or quantitatively, could be followed from this baseline in subsequent examinations.

Reproducibility of clinical gradient. We have analysed the data collected at four intervals during the course of this study—namely, when 101, 178, 205 and, finally, 278 individuals in our sample had been examined. The results, given in Table XL, show general uniformity, and the differences noted are explainable on the basis of certain highly endemic zones (Malirong and Gacao) being covered during the period ending February 1955. Such reproducibility in the community surveyed gives us confidence in the classification we have adopted.

TABLE XXXIX. CLINICAL GRADIENT OF A RANDOM SAMPLE OF 278 SCHISTOSOME-INFECTED INDIVIDUALS ARRANGED ACCORDING TO SEX IN PALO AND ITS THREE DIVISIONS (DECEMBER 1954—AUGUST 1955)

Town and divisions	Sex	Number examined	Asymptomatic		Symptomatic		Mild		Moderate		Severe		Very severe
			number	%	number	%	number	%	number	%	number	%	
Palo	Male	138	82	59.4	56	40.6	31	55	21	38	4	7	
	Female	140	91	65.0	49	35.0	29	59	20	41	0	0	
Población	Male	49	25	71	14	29	7	50	7	50	0	0	
	Female	42	32	76	10	24	5	50	5	50	0	0	nil
Coastal	Male	42	21	50	21	50	16	76	5	24	0	0	
	Female	41	25	61	16	39	15	94	1	6	0	0	
Inland	Male	47	26	55	21	45	8	38	9	43	4	19	
	Female	57	34	60	23	40	9	39	14	61	0	0	

TABLE XL. PERIODIC SUMMARY OF THE CLASSIFICATION OF MORBIDITY IN 278 SCHISTOSOME-INFECTED INDIVIDUALS IN PALO, INCLUDING STATUS OF HEPATOMEGALY AND SPLENOMEGALY (DECEMBER 1954—AUGUST 1955)

Number examined	Period ending	Asymptomatic		Symptomatic		Mild		Moderate		Severe		Very severe		Liver		Spleen	
		number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%
101	February 1955	59	58.4	42	41.6	22	52	16	38	4	10	0	0	36	35.6	3	3.0
178	April 1955	96	53.9	82	46.1	57	70	21	26	4	5	0	0	60	33.7	3	1.7
205	May 1955	116	56.6	89	43.4	61	69	24	27	4	4	0	0	70	34.1	5	2.4
278	July 1955	173	62.2	105	37.8	60*	57	41	39	4	4	0	0	102**	37.4	8**	2.9

* Corrections made later on the basis of Hb examinations.

** Out of 273, 5 women refused physical examination.

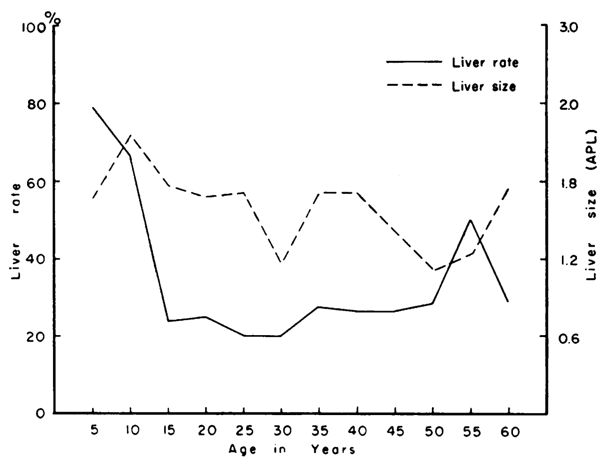
TABLE XLI. AGE DISTRIBUTION OF HEPATOMEGALY AND SPLENOMEGALY IN A RANDOM SAMPLE OF 278 * SCHISTOSOME-INFECTED INDIVIDUALS EXAMINED IN PALO (DECEMBER 1954—AUGUST 1955)

Age-group (years)	Number examined	Liver										Spleen							
		number with palpable liver	liver rate	liver size							APL	number with enlarged spleen	spleen rate	spleen size					AES
				0.5	1	1.5	2	2.5	3	3+				1	2	3	4	5	
Below 5	1	0	0	—	—	—	—	—	—	—	0	0	0	—	—	—	—	—	0
5-9	23	18	78	—	6	1	10	1	—	—	1.67	0	0	—	—	—	—	—	0
10-14	49	33	67	—	2	1	22	2	6	—	2.14	1	2	—	1	—	—	—	2.0
15-19	38	9	24	—	3	—	5	—	1	—	1.78	0	0	—	—	—	—	—	0
20-24	23	6	26	—	2	1	2	1	—	—	1.67	0	0	—	—	—	—	—	0
25-29	25	5	20	—	2	—	2	1	—	—	1.70	0	0	—	—	—	—	—	0
30-34	15	3	20	—	2	1	—	—	—	—	1.17	2	13	—	1	1	—	—	2.5
35-39	22	6	27	—	3	1	—	1	1	—	1.67	0	0	—	—	—	—	—	0
40-44	19	5	26	1	1	—	2	—	1	—	1.70	1	5	—	—	1	—	—	3.0
45-49	19	5	26	—	3	—	2	—	—	—	1.40	2	11	—	—	1	1	—	3.5
50-54	14	4	29	—	3	1	—	—	—	—	1.13	1	7	—	—	—	1	—	4.0
55-59	7	3	43	—	3	—	—	—	—	—	1.00	1	14	—	1	—	—	—	2.0
60 and over	18	5	28	—	3	—	—	1	1	—	1.70	0	0	—	—	—	—	—	0
Total	273	102	37.4	1	33	6	45	7	10	—	1.76	8	2.9	0	3	3	2	0	2.88

* Of the 278 individuals in the sample, five women refused physical examination.

Status of hepatomegaly and splenomegaly. Particulars noted in regard to hepatomegaly and splenomegaly have been recorded in relation to area, age and sex. Fig. 22 shows the relationship of liver rate and liver size respectively, in the different age-groups.

FIG. 22. LIVER RATE AND LIVER SIZE IN RELATION TO AGE IN SCHISTOSOME-INFECTED INDIVIDUALS IN PALO



Liver rate is highest in the age-groups 5-9 and 10-14 years (Table XLI). The difference noted between these two groups is not significant, nor are the differences among the age-groups above 14 years. Liver size also reaches a maximum in the age-group 10-14 years. Table XLII shows the relationship of hepatomegaly to sex. There is no significant difference in either the liver rate or the liver size between males and females.

Particulars of hepatomegaly in the three environmental divisions are given in Table XLIII, and illustrated in Fig. 23, to show the relationship of liver size to the prevalence of infection. The liver rate in the coastal area is significantly lower than in the inland area or the población.

A high proportion of liver enlargement was found to be unassociated with splenomegaly; out of the 102 individuals with palpable livers only 5 had associated splenomegaly. No ascites was found in any of these cases.

Egg counts. Table XLIV gives the counts of eggs of schistosomes and other helminths in stools, made to determine the " worm burden " among individuals in this longitudinal study. The mean number of schistosome eggs in stools bears a close relationship to the frequency distribution of symptomatic cases in the different age-groups, with the peak for both in the 10-14-year group and an accompanying fall in both with advancing age (Fig. 24).

TABLE XLII. SEX DISTRIBUTION IN RELATION TO LIVER SIZE AMONG THE 105 * SYMPTOMATIC CASES IN PALO AND ITS THREE DIVISIONS (DECEMBER 1954—AUGUST 1955)

Town and division	Sex	Number examined	Number with palpable liver	Liver rate	Liver size							APL
					0.5	1	1.5	2	2.5	3	3+	
Palo	Male	56	24	43	—	4	1	13	2	4	0	2.02
	Female	48	24	50	—	7	1	13	1	2	0	1.79
Población	Male	14	7	50	—	1	1	3	1	1	—	2.00
	Female	10	8	80	—	1	1	4	1	1	—	2.00
Coastal	Male	21	7	33	—	2	—	3	1	1	—	1.93
	Female	16	5	31	—	3	—	2	—	—	—	1.40
Inland	Male	21	10	48	—	1	—	7	—	2	—	2.10
	Female	22*	11	50	—	3	—	7	—	1	—	1.82
Total of males and females		104*	48	46	—	11	2	26	3	6	0	1.91

* Of the 105 symptomatic cases seen in the sample, a woman from the inland division refused physical examination.

Over 90% of the individuals (236 out of 260) were positive for one or more of the intestinal helminths—*Ascaris*, 75.4%; *Trichuris*, 90.7%; and *Ancylostoma*, 75.4%. The intensity of *Ascaris* and *Trichuris* infections reaches a maximum in the age-groups 5-9 and 10-14 years, respectively, which corresponds to their general prevalence rates in the community. No other definite trend is discernible in respect of the egg counts of these three parasites.

TABLE XLIII. PARTICULARS OF HEPATOMEGALY IN A RANDOM SAMPLE OF 278 * SCHISTOSOME-INFECTED INDIVIDUALS IN PALO AND ITS THREE DIVISIONS (DECEMBER 1954—AUGUST 1955)

Town and division	Number examined	Number with palpable liver	Liver rate	Liver size							APL
				0.5	1	1.5	2	2.5	3	3+	
Palo (total)	273 *	102	37.4	1	33	6	45	7	10	0	1.76
Población	91	38	42	1	15	5	9	6	2	0	1.63
Coastal	83	21	25	0	7	0	11	1	2	0	1.79
Inland	99 *	43	43	0	11	1	25	0	6	0	1.88

* Of the 278 individuals in the sample under study, 5 women from the inland division refused physical examination.

FIG. 23. RELATIONSHIP OF HEPATOMEGALY TO PREVALENCE OF SCHISTOSOME INFECTION IN PALO AND ITS THREE DIVISIONS

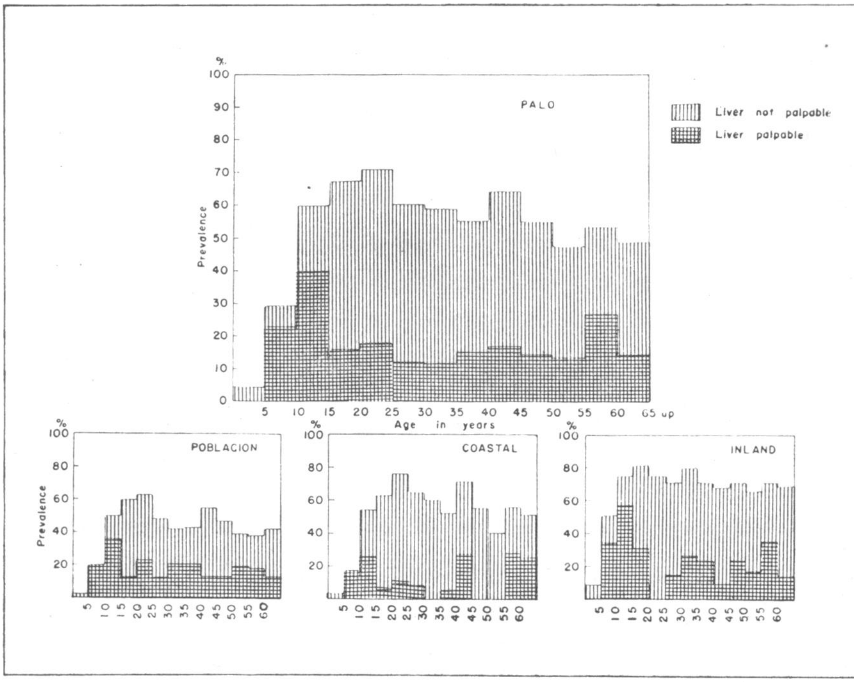


FIG. 24. RELATIONSHIP OF *SCHISTOSOMA* EGG-COUNTS IN STOOLS TO SYMPTOMATIC CASES BY AGE-GROUP

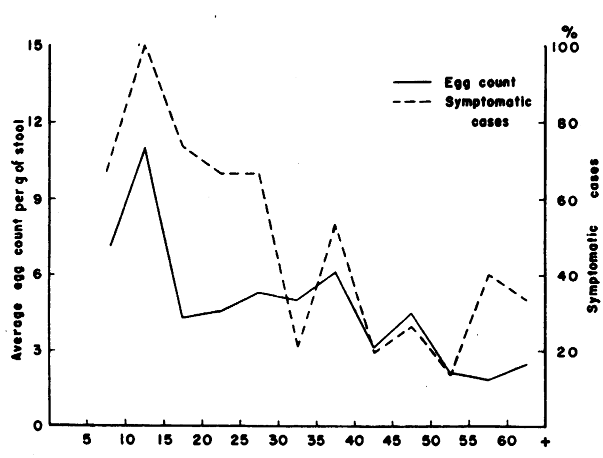


TABLE XLIV. AVERAGE NUMBER OF SCHISTOSOME AND OTHER HELMINTH EGGS PER ml OF STOOL IN 260 * INDIVIDUALS IN PALO

Age-group (years)	Number examined	Average count of eggs per ml of faeces			
		Ascaris	*Trichuris*	*Ancylostoma*	*Schistosoma*
Below 5	1	5 900	800	0	0
5-9	22	19 309	1 886	623	10
10-14	48	18 023	2 985	483	15
15-19	31	9 823	1 097	471	11
20-24	20	7 535	865	480	10
25-29	27	3 804	726	319	10
30-34	15	8 160	1 247	800	3
35-39	20	8 040	585	445	8
40-44	18	11 189	2 322	294	3
45-49	19	7 311	668	442	4
50-54	13	4 731	469	500	2
55-59	8	2 425	713	675	6
60 and over	18	12 794	1 556	1 089	5
Total	260 *	10 725	1 466	522	9

* Out of 278 individuals in the sample, stools could not be collected from 18 persons. Schistosome egg count was made using MIFC technique and counts for eggs of other helminths by the Stoll technique. Counts not corrected to formed stool basis.

Twenty individuals (7.7%) have become negative for *Schistosoma* ova (on the basis of three stool examinations by the MIFC technique) since they were last examined in 1953-54. Eighteen of them are from the población and the coastal zone and only two from the inland zone. Twelve (60%) are over 25 years of age. These individuals will be carefully followed up along with the rest of the sample.

Of the 28 individuals who excreted relatively large number of schistosome eggs (20 or over per ml of stool), 16 are in the age-group 7-14 years, 12 are between 15 and 36 years of age, and none are above that age. In the first group, 11 (69%) manifest symptoms of a severe degree, whereas in the latter group only 3 (25%) have ailments of a minor degree.

Conclusion

Children in the age-group 10-14 years bear the brunt of the disease. The inescapable impression gained is that bilharziasis in this area provides another instance of a successful parasitism which allows a large proportion of individuals to live in a state of natural balance with the parasite without their normal life being too profoundly disturbed. A growing tolerance to the infection appears to suppress clinical manifestations, and acute attacks become infrequent once the individuals get past the most vulnerable age (10-14 years). Infection among adults in this endemic area, therefore, is not synonymous with disease. This can only be explained on the basis of immunity developing as a result of constant exposures to schistosome infection from the early years of life up to the point where a further quantum of infection is prevented. The true nature of this phenomenon, however, needs precise definition in terms of immunology.

Careful experimental evidence obtained by Vogel & Minning (1953), utilizing *Macacus rhesus* over a period of several years (1938-50) for their studies on the development of acquired resistance to superinfection with *S. japonicum*, admirably supports the conclusion we have reached on the basis of the epidemiological observations in this area.

Suggested method of evaluating economic burden of bilharziasis

The fundamental importance of estimating the economic burden of disease has been stressed by Winslow (1951) in his monograph *The Cost of Sickness and the Price of Health*, showing that every step that can be taken towards lessening the disease burden will not only diminish suffering and prolong human life but will also increase productivity and promote prosperity. It is common experience that a control programme, especially one against such an unspectacular chronic disease as bilharziasis, has to be presented as a profitable enterprise to attract financial support and, more particularly, to give it its due place in the priorities which must be considered by governments in the use of their available funds. Such estimates have been made in many countries in respect of many other diseases, and they have been used to great advantage by public health administrators in obtaining sanction for their cost estimates of control measures, considered purely as worthwhile investments quite apart from the moral issues involved.

In the Philippines, such estimates have been made for malaria (Ejercito and colleagues, 1954) and for tuberculosis (Padua, 1952), totalling an estimated loss equivalent to $33 per head of population per year due to these two diseases. These estimates are based on the annual number of recorded deaths from these diseases.

Similar information is meagre in respect of bilharziasis, and we have to depend on some measurement of morbidity for the purpose. Estimates have been made by Wright (1950) of the loss involved in the case of the epidemic of *S. japonicum* among the US forces in Leyte in 1944 at 300 000 man-days and immediate medical care cost of approximately $3 000 000, not covering subsequent veterans' benefits. In Egypt, it is estimated that bilharziasis costs the country approximately $57 million a year and lowers the productivity of the population by 33% (Wright & Dobrovolny, 1953).

Hunter and associates (1952), in discussing the possible eradication of bilharziasis from each of the five endemic areas of Japan by a 5-7 years' programme of mollusciciding, stated that it would result in an eventual saving of a sum of almost $3 million per year. This estimate was based on the following data furnished by officials of the prefectures of Fukuoka and Saga:

Estimated number of cases	28 617
Man-hours lost per year	24 213 520
Estimated cost of current treatment of infected persons per year	$177 938
Wages lost per year	$2 522 200

It is not mentioned how these figures were arrived at. Gordon (1953), in reviewing the above work, mentions the fact that he and Professor T. H. Davey during a visit to the cotton-growing areas of the Anglo-Egyptian Sudan, where *S. mansoni* and *S. haematobium* infections are prevalent in the labour forces, failed to obtain reliable evidence for or against any marked loss of man-power attributable to infection with one or both of these parasites.

Our endeavour, therefore, is to arrive at a rational basis on which to make as closely approximate an estimate as possible of the economic burden involved. A possible method of approach which we are pursuing is briefly stated here.

In the second follow-up of the infected individuals in the longitudinal study we have described, " spells " of illnesses referable to bilharziasis, and the duration and severity of each spell during the time interval between the first and second follow-up are being recorded. From the data gathered, it should be possible to calculate the frequency rate of illness, the severity rate (days per illness), and a disability rate (days of illness per person). As loss of working capacity is an element in our classification, we should be able to make an acceptable estimate of the man-days lost per year and of the economic loss sustained by the community.

The question will arise how to sort out the effect of helminthic and other intestinal infections which could well cause some of the symptoms we have included in our classification of the disease. The only possible course available to us is, as we have planned, to carry out a parallel study in a representative sample among bilharziasis-free individuals in Carigara, our check area. As we have pointed out earlier, the prevalence of helminthic infections in Carigara is equal to that in Palo, and since the populations in the pilot area and the check area are similar in other relevant respects, we should be able to eliminate the effect of conditions other than bilharziasis by measuring the differences in morbidity in these two areas in respect of the symptomatology.

All this will be time-consuming, but we see no other satisfactory way of answering this difficult question. We feel, however, that this project provides an opportunity of obtaining estimates of the economic burden of bilharziasis as a by-product of the studies on the natural history of the disease.

Incidence of disease in children 5-9 years old

Throughout this discussion we have used the word *prevalence* to indicate the number of infected persons in relation to time, place and size of population examined. This is a static measurement as compared to *incidence*. The latter term, as defined by the American Public Health Association (1955), is used to express the number of persons infected during a prescribed period in relation to the unit of population in which they occur (a dynamic measurement); we have expressed this as a percentage per annum.

Very often these two terms are not clearly differentiated and they are not infrequently confused. Recognition of the difference is essential, and the determination of these two indices is fundamental to epidemiology, " as fundamental as the determination of temperature, pulse and respiration in clinical medicine " (Gordon, 1950). Prevalence is the product of incidence times duration. Killing diseases running a rapid course will generally show a lower prevalence than diseases that do not kill so fast and run a prolonged course. If one disease has one-fifth the incidence of a second disease in a given population, but runs on the average a course of five years asymptomatically, while the second runs a course of one year, the finding in terms of numbers of cases of the two diseases (prevalence) in an initial survey will be the same. The repetition of the screening, however, will bring out the real difference between the two diseases (Dunn, 1956; Perkins, 1950; Pope & Gordon, 1955).

In view of considerations such as these, and in order to obtain a baseline on the rate of transmission, of which incidence is a reliable measure, we have been led to start this " longitudinal " study on children in the age-group 5-9 years. This will also enable us to follow up the course of the disease among young children, who are the first to come in contact with the infection in this hyper-endemic area.

Materials and methods

Examination of records of the prevalence survey conducted about two years previously (1953-54) in the pilot area showed that of 489 children examined in the age-group 3-7 years 407 were negative. A 50% subsample from the negative children was drawn from the 14 zones of Palo, by reference to the table of random numbers. This gave us a sample of 200 children in 5-9-year age-group for this study.

A careful record of interviews with the mothers, physical examinations, haemoglobin estimations, eosinophil counts and stool examinations of these children was conducted by one of us throughout the period by house-to-house visits. A second medical opinion was also available. An average of 3-4 children were examined in an afternoon.

TABLE XLV. ANNUAL INCIDENCE OF BILHARZIASIS IN PALO AND ITS THREE DIVISIONS, IN EACH YEAR OF AGE-GROUP 5-9 (JULY—DECEMBER 1955)

Town and division	Age (years)	Number examined	Number positive	Average duration of exposure	Annual incidence * (%)
Palo	5	25	7	20	18
	6	46	9	21	12
	7	49	16	22	19
	8	33	17	21	31
	9	47	21	23	25
	Total	200	70	22	20.4
Población	5	6	0	21	0
	6	18	2	25	6
	7	19	5	23	15
	8	13	3	25	12
	9	16	6	25	19
	Subtotal	72	16	24	12
Coastal	5	7	1	19	10
	6	18	0	19	0
	7	19	2	19	7
	8	6	2	18	24
	9	23	8	21	21
	Subtotal	73	13	20	11
Inland	5	12	6	20	32
	6	10	7	19	47
	7	11	9	23	46
	8	14	12	19	58
	9	8	7	23	49
	Subtotal	55	41	21	46

* Corrected on the basis of three stool examinations.

TABLE XLVI. ANNUAL INCIDENCE OF BILHARZIASIS BY SEX IN AGE-GROUP 5-9 IN PALO AND ITS THREE DIVISIONS (JULY-DECEMBER 1955)

Town and division	Sex	Number examined	Number positive	Average duration	Annual incidence * (%)
Palo	Male	105	35	22	19.4
	Female	95	35	22	21.5
	Total	200	70	22	20.4
Población	Male	41	12	24	16
	Female	31	4	24	7
	Subtotal	72	16	24	12
Coastal	Male	43	7	19	11
	Female	30	6	21	12
	Subtotal	73	13	20	11
Inland	Male	21	16	21	47
	Female	34	25	21	45
	Subtotal	55	41	21	46

* Corrected for three stool examinations.

A child was regarded as negative on the basis of three consecutive negative stool examinations by the MIFC technique.

The first screening, which started in July 1955, was completed in December 1955.

Incidence of bilharziasis. Of the 200 children examined 70 acquired the infection during an average time interval of 22 months, giving an annual incidence rate of 20.4%.[a]

Incidence attains a peak in the 8th year of life (Table XLV); sex differences are not significant (Table XLVI).

The incidence in the población is 12%, in the coastal area 11% and in the inland area 46%. Not only is the incidence in the inland area approximately four times as high as in the other two divisions, but the children seem to acquire the infection earlier in life in this area; next in order comes the población and lastly the coastal area, where the infection is further delayed (Table XLVII). This is in accord with our findings on general prevalence and depends on the relative opportunities for infection which the varying environments provide.

[a] Necessary correction has been made for the fact that the basis of a negative case in the present study is 3 consecutive negative stool examinations as against a single examination in the first survey. The single examination has been determined to miss 6.5% of positives in this age-group.

TABLE XLVII. AGE DISTRIBUTION OF 70 SCHISTOSOME-INFECTED CHILDREN IN PALO AND ITS THREE DIVISIONS

Age (years)	Palo		Población		Coastal		Inland	
	frequency	%	frequency	%	frequency	%	frequency	%
5	7	10	0	0	1	8	6	15
6	9	13	2	13	0	0	7	17
7	16	23	5	31	2	15	9	22
8	17	24	3	19	2	15	12	29
9	21	30	6	38	8	62	7	17
Total	70	100	16	100	13	100	41	100

Clinical features of the disease. Of the 70 schistosome-positive children, 31 (44.3%) had abdominal pain and diarrhoea with or without bloody stools, fever or other symptoms. Although this did not clearly imply a particular consequence, it was perhaps sufficient to make a presumptive diagnosis of bilharziasis in an endemic area. The remaining 39 (55.7%) had no suggestive history or only suffered a vague illness with one or more of the less pathognomonic symptoms listed below. No typical syndrome of an early invasive stage could be obtained from any child, and it could be concluded that in a majority of cases in Palo the onset of the disease is insidious.

The symptoms occurring among the 70 bilharziasis-positive children were as follows:

Symptom	*Frequency*	*Percentage*
Abdominal pain	34	20.7
Diarrhoea	26	15.9
Blood in stool	16	9.8
Fever	44	26.8
Anorexia	1	0.6
Vomiting	2	1.2
Headache	2	1.2
Epistaxis	2	1.2
Cough	16	9.8
Convulsions	1	0.6
Fainting	1	0.6
Chest pain	1	0.6
Night blindness	18	11.0
Total	164	100.0

Of the 130 bilharziasis-negative children, 35 (26.9%) suffered from gastro-intestinal disturbances which could also be regarded as clinical manifestations of intestinal helminthiasis as all children were found infected with two or more helminthic parasites.

Prevalence of intestinal helminths. All children examined are found to be infected with at least two of the three common helminths, the mean number of infections per child being 2.5.

Over 95% of children are infected with *Ascaris* and over 85% with *Trichuris* by the time they are 5 years old. *Ancylostoma* infection rises significantly from a comparatively low level of 50% at the age of 5 to 71% by the age of 8 years. It apparently builds up as the children grow and run about farther from the immediate vicinity of their houses.

TABLE XLVIII. AREA PREVALENCE OF INTESTINAL HELMINTHS IN 191 CHILDREN IN AGE-GROUP 5-9, IN PALO AND ITS THREE DIVISIONS (MARCH-APRIL 1956)*

Town and division	Number examined	Positive for *Ascaris*		Positive for *Trichuris*		Positive for *Ancylostoma*	
		number	%	number	%	number	%
Palo (total)	191	177	92.7	178	93.2	119	62.3
Poblaci6n	70	66	94	66	94	33	47
Coastal	67	60	90	64	96	46	69
Inland	54	51	94	48	89	40	74

* On the basis of a single stool examination by the MIFC technique

The small differences in the prevalence of *Ascaris* and *Trichuris* in the three environments are not valid but there is a significantly higher prevalence of *Ancylostoma* infection in the inland and the coastal divisions (Table XLVIII).

Intensity of helminthic infections. Following the classification of Keller & Leathers (1936) for *Ascaris* and *Trichuris*, and Keller, Leathers & Knox (1937) for *Ancylostoma*, the average intensities of infections would fall into the following categories (see also Fig. 25):

Parasite	*Eggs per ml of stool*	*Intensity*
Ascaris	52 533	Moderate
Trichuris	5 929	Heavy
Ancylostoma	1 671	Light
Schistosoma	41	—

These figures show the average number of eggs in stools of 191 of the 200 5-9-year-old children in the Palo sample, examined in March-April 1956; specimens

FIG. 25. INTENSITY OF COMMON HELMINTHIC INFECTIONS IN CHILDREN 5-9 YEARS OLD IN PALO (MARCH-APRIL 1956)

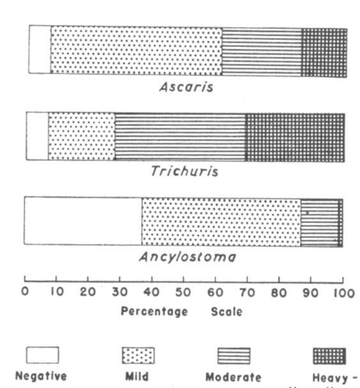


TABLE XLIX. CLASSIFICATION OF INTENSITY OF *ASCARIS* INFECTION IN 177 POSITIVE CHILDREN IN PALO AND ITS THREE DIVISIONS AS DETERMINED BY THE STOLL COUNT * (MARCH-APRIL 1956)

Intensity of infection	Eggs per ml of faeces	Total for Palo		Población		Coastal		Inland	
		number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%
Very light	200–9 999	43	24.3	12	18	14	23	17	33
Light	10 000–49 999	59	33.3	20	30	19	32	20	39
Moderate	50 000–99 999	50	28.2	22	33	15	25	13	25
Heavy	100 000–299 999	25	14.1	12	18	12	20	1	2
Very heavy	300 000 and over	0	0	0	0	0	0	0	0
Total		177	100.0	66	100	60	100	51	100

* Adapted from Keller & Leathers (1936); and corrected to formed stool basis.

from the other 9 children could not be collected for re-examination. The methods used were the MIFC technique for *Schistosoma* eggs and the Stoll count for other helminths, corrected to formed stool basis.

TABLE L. CLASSIFICATION OF INTENSITY OF *ASCARIS* INFECTION ACCORDING TO AGE IN 177 POSITIVE CHILDREN, AS DETERMINED BY STOLL COUNT * (MARCH-APRIL 1956)

Intensity of infection	Eggs per ml of faeces	Age 5 years		Age 6 years		Age 7 years		Age 8 years		Age 9 years		Total	
		number	%	number	%	number	%	number	%	number	%	number	%
Very light	200–9 999	4	17	9	21	14	32	4	14	12	31	43	24.3
Light	10 000–49 999	12	52	11	26	15	34	10	34	11	28	59	33.3
Moderate	50 000–99 999	4	17	12	29	10	23	15	52	9	23	50	28.2
Heavy	100 000–299 999	3	13	10	24	5	11	0	0	7	18	25	14.1
Very heavy	300 000 and over	0	0	0	0	0	0	0	0	0	0	0	0
Total		23	100	42	100	44	100	29	100	39	100	177	100.0

* Adapted from Keller & Leathers (1936); and corrected to formed stool basis.

TABLE LI. CLASSIFICATION OF INTENSITY OF *TRICHURIS* INFECTION IN 178 POSITIVE CHILDREN IN PALO AND ITS THREE DIVISIONS, AS DETERMINED BY STOLL COUNT * (MARCH-APRIL 1956)

Intensity of infection	Eggs per ml of faeces	Total for Palo		Poblacion		Coastal		Inland	
		number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%
Light	100–999	40	22.5	7	11	14	22	19	40
Moderate	1 000–4 999	79	44.4	37	56	22	34	20	42
Heavy	5 000–9 999	29	16.3	13	20	10	16	6	13
Very heavy	10 000 and over	30	16.9	9	14	18	28	3	6
Total		178	100.0	66	100	64	100	48	100

* Adapted from Keller & Leathers (1936); and corrected to formed stool basis.

Moderate to heavy *Ascaris* infection occurs in 42.3% of children, with the intensity reaching its maximum in the 6th year (Tables XLIX and L). Moderate to heavy and very heavy *Trichuris* infection is found in 77.6% of children, the intensity reaching its maximum for the group in the 8th year (Tables LI and LII).

Moderate to heavy *Ancylostoma* infections are seen in 20.1% of children,

TABLE LII. CLASSIFICATION OF INTENSITY OF *TRICHURIS* INFECTION ACCORDING TO AGE IN 178 POSITIVE CHILDREN, AS DETERMINED BY STOLL COUNT * (MARCH-APRIL 1956)

Intensity of infection	Eggs per ml of faeces	Age 5 years		Age 6 years		Age 7 years		Age 8 years		Age 9 years		Total	
		number	%	number	%	number	%	number	%	number	%	number	%
Light	100–999	8	38	6	15	10	22	3	10	13	31	40	22.5
Moderate	1 000–4 999	9	43	20	49	21	47	13	45	16	38	79	44.4
Heavy	5 000–9 999	2	10	6	15	9	20	5	17	7	17	29	16.3
Very heavy	10 000 and over	2	10	9	22	5	11	8	28	6	14	30	16.9
Total		21	100	41	100	45	100	29	100	42	100	178	100.0

* Adapted from Keller & Leathers (1936); and corrected to formed stool basis.

TABLE LIII. CLASSIFICATION OF INTENSITY OF *ANCYLOSTOMA* INFECTION IN 119 CHILDREN POSITIVE IN PALO AND ITS THREE DIVISIONS, AS DETERMINED BY STOLL COUNT * (MARCH-APRIL 1956)

Intensity of infection	Eggs per ml of faeces	Total for Palo		Población		Coastal		Inland	
		number of indivi-duals	%	number of indivi-duals	%	number of indivi-duals	%	number of indivi-duals	%
Very light	100–699	46	38.7	13	39	17	37	16	40
Light	700–2 599	49	41.2	13	39	18	39	18	45
Moderate	2 600–12 599	23	19.3	7	21	10	22	6	15
Heavy	12 600–24 999	1	0.8	0	0	1	2	0	0
Very heavy	25 000 and over	0	0	0	0	0	0	0	0
Total		119	100.0	33	100	46	100	40	100

* Adapted from Keller, Leathers & Knox (1937); and corrected to formed stool basis.

with the intensity reaching the maximum for the group in the 9th year (Tables LIII and LIV).

Classified in relation to the environmental divisions of Palo (Tables XLIX, LI and LIII), *Ascaris* and *Trichuris* infections are noted to be heavier

TABLE LIV. CLASSIFICATION OF INTENSITY OF *ANCYLOSTOMA* INFECTION ACCORDING TO AGE IN 119 POSITIVE CHILDREN, AS DETERMINED BY STOLL COUNT * (MARCH-APRIL 1956)

Intensity of infection	Eggs per ml of faeces	Age 5 years		Age 6 years		Age 7 years		Age 8 years		Age 9 years		Total	
		number	%	number	%	number	%	number	%	number	%	number	%
Very light	100–699	5	42	13	52	10	33	3	14	15	50	46	39
Light	700–2 599	6	50	10	40	13	43	13	59	7	23	49	41
Moderate	2 600–12 599	1	8	2	8	7	23	6	27	7	23	23	19
Heavy	12 600–24 999	0	0	0	0	0	0	0	0	1	3	1	1
Very heavy	25 000 and over	0	0	0	0	0	0	0	0	0	0	0	0
Total		12	100	25	100	30	100	22	100	30	100	119	100

* Adapted from Keller, Leathers & Knox (1937); and corrected to formed stool basis.

in the población and the coastal than in the inland divisions. The difference is not significant for *Ancylostoma*. The type of terrain and the clay loam soil in the inland area seem to be less favourable for intestinal helminths than the porous sandy soil of the coastal area. Flooding is common in the inland area following rains, a very favourable condition for the transmission of bilharziasis. This would account for its higher intensity in the area, a finding in general consonance with the data obtained in an earlier study.

Water covering soils containing *Ancylostoma* larvae is considered to cause their destruction by the growth of bacteria, fungi and protozoa, which are larvicidal (Faust, 1949). That porous moist soil, with the necessary shade and warmth, serves as a good culture medium for *Ancylostoma* larvae has been observed by several workers. This would also conform with the general finding that heavy *Ancylostoma* infection is not associated with rice culture in general, but the infested sweet potato (" camote ") fields in these areas would constitute fruitful sources of infection.

In our view, submergence of *Ascaris* and *Trichuris* could possibly have an unfavourable effect on these parasites, and had it not been for the frequent inundations due to rains, conditions in respect of the intestinal helminths might have been much worse in the inland areas of Palo.

A tentative classification of intensity for bilharziasis has also been made, but the small figures involved do not allow of any valid conclusions being drawn in respect of age or sex (Tables LV and LVI).

It should, however, be pointed out that the quantitative determination of eliminated eggs, so profitably employed to estimate the burden of intestinal helminths, suffers from the conspicuous drawback that many

TABLE LV. CLASSIFICATION OF INTENSITY OF SCHISTOSOME INFECTION IN 55 POSITIVE CHILDREN IN PALO AND ITS THREE DIVISIONS, AS DETERMINED BY MIFC COUNT * (MARCH-APRIL 1956)

Eggs per ml of faeces	Total for Palo		Población		Coastal		Inland	
	number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%
1–19	35	64	7	70	8	80	20	56
20–39	9	16	0	0	1	10	8	22
40–59	4	7	2	22	0	0	2	6
60 and over	7	13	0	0	1	10	6	17
Total	55	100	9	100	10	100	36	100

* Corrected to formed stool basis

TABLE LVI. CLASSIFICATION OF INTENSITY OF SCHISTOSOME INFECTION IN 55 POSITIVE CHILDREN IN PALO AND ITS THREE DIVISIONS AS DETERMINED BY MIFC COUNT * (MARCH-APRIL 1956)

Eggs per ml of faeces	Age 5 years		Age 6 years		Age 7 years		Age 8 years		Age 9 years		Total	
	number	%	number	%	number	%	number	%	number	%	number	%
1–19	3	50	3	60	8	73	8	57	13	68	35	64
20–39	2	33	2	40	1	9	1	7	3	16	9	16
40–59	0	0	0	0	1	9	1	7	2	11	4	7
60 and over	1	17	0	0	1	9	4	29	1	5	7	13
Total	6	100	5	100	11	100	14	100	19	100	55	100

* Corrected to formed stool basis

of the *Schistosoma* eggs are retained in the host tissues and are not included in the counts, which therefore cannot be used as a true measure of the intensity of the infection (Vogel & Minning, 1953). Nevertheless, a measure of correlation between egg output and disease severity has been shown to exist (see the section on quantitative assessment of disease, above).

Hepatomegaly, anaemia and eosinophilia. The data on hepatomegaly are presented in Table LVII for the bilharziasis-positive and -negative groups of children. There is no statistically valid difference in the liver rates and liver sizes in the two groups. The liver rates reach the peak in the 5-year-olds, and thereafter there is a general decline in both groups.

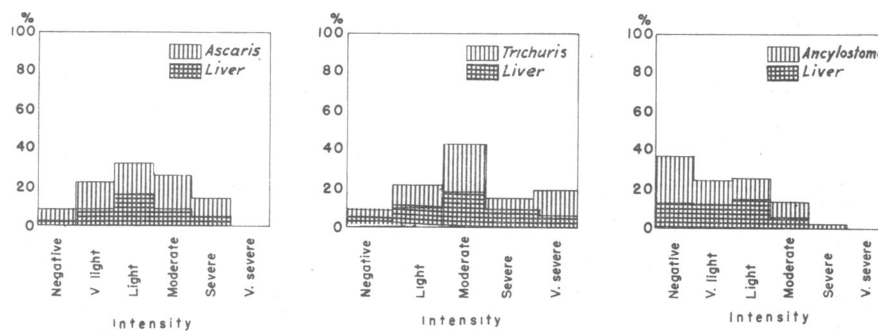
TABLE LVII. STATUS OF HEPATOMEGALY IN CHILDREN POSITIVE AND NEGATIVE FOR BILHARZIASIS IN PALO (JULY-DECEMBER 1955)

	Age (years)					Total
	5	6	7	8	9	
Bilharziasis-positive						
Examined	7	9	16	17	21	70
Liver palpable	6	6	7	8	6	33
Liver rate	86	67	44	47	29	47
Liver size (APL)	1.83	2.16	1.43	1.87	2.08	1.89
Bilharziasis-negative						
Examined	18	37	33	16	26	130
Liver palpable	11	11	15	4	9	50
Liver rate	61	30	45	25	35	38.5
Liver size (APL)	1.60	1.72	1.76	1.75	1.77	1.72

Livers are predominantly soft (82%) with a smooth surface and mostly with a rounded edge. Tenderness is rare except on deep pressure. There is no evidence of portal obstruction or jaundice or associated splenomegaly.

Fig. 26 based on Table LVIII does not indicate the existence of a correlation between intensity of *Ascaris* and *Trichuris* infections to hepatomegaly; nor is a clear relationship evident in respect of *Ancylostoma* infection. How much of the related hepatomegaly is solely caused by parasitic infections and how much is produced by it in association with dietary deficiency, we are unable to say at this stage.

FIG. 26. RELATIONSHIP OF INTENSITY OF HELMINTHIC INFECTION TO HEPATOMEGALY IN CHILDREN 5-9 YEARS OLD



A rapid survey of approximately 100 children in some schistosome-free and other mildly infected barrios of Carigara in 1955 by R. C. Burgess and F. W. Clements on behalf of the WHO Regional Office for the Western Pacific showed a much higher rate of hepatomegaly in the groups 1-4 years and a decrease in the older age-groups. It was concluded that hepatomegaly among children in this area would seem to be of multiple etiology. Nutritional deficiency aggravated by high helminthic prevalence among children would suggest itself as a probable cause requiring fuller investigations.

Because of the infrequency of dramatic episodes, the role of *Ascaris* as a cause of morbidity in this area has been insufficiently appreciated, particularly in young children on borderline nutrition. Jelliffe (1953) has drawn attention to the fact that *Ascaris* is often an important accessory in the etiology of malnutrition in children, especially in the production of the kwashiorkor nutritional oedema syndrome. This view has been emphasized by Williams (1938) from Malaya and the Gold Coast (Ghana); Achar (1950) from India; De Silva (1950) from Ceylon; and Venkatachalam & Patwardhan (1953) from southern India.

TABLE LVIII. RELATIONSHIP OF INTENSITY OF INFECTION WITH *ASCARIS*, *TRICHURIS* AND *ANCYLOSTOMA* TO HEPATOMEGALY IN 191 CHILDREN IN AGE-GROUP 5-9 YEARS (JULY-APRIL 1956)

Classification of intensity *	Eggs per ml of faeces	Children examined		Children with palpable liver	
		number	%	number	percentage of total examined
			Ascaris		
Negative	0	14	7.3	4	2.1
Very light	200– 9 999	43	22.5	18	9.4
Light	10 000– 49 999	59	30.9	29	15.2
Moderate	50 000– 99 999	50	26.2	18	9.4
Severe	100 000–299 999	25	13.1	9	4.7
Very severe	300 000 and over	0	0	0	0
Total		191	100.0	78	40.8
			Trichuris		
Negative	0	13	6.8	4	2.1
Light	100– 999	40	20.9	16	8.4
Moderate	1 000– 4 999	79	41.4	32	16.8
Severe	5 000– 9 999	29	15.2	16	8.4
Very severe	10 000 and over	30	15.7	10	5.2
Total		191	100.0	78	40.8
			Ancylostoma		
Negative	0	72	37.7	22	11.5
Very light	100– 699	46	24.1	21	11.0
Light	700– 2 599	49	25.9	27	14.1
Moderate	2 600– 12 599	23	12.0	8	4.0
Severe	12 600– 24 999	1	0.5	0	0
Very severe	25 000 and over	0	0	0	0
Total		191	100.0	78	40.8

* Classification of intensity based on that of Keller & Leathers (1936) and Keller, Leathers & Knox (1937).

A fairly high rate of eosinophilia and low haemoglobin is a common feature among the children examined; differences in these values (although not statistically significant) are noted among the liver-palpable and the liver-not-palpable groups (Table LIX).

TABLE LIX. HAEMOGLOBIN AND EOSINOPHIL VALUES WITH PALPABLE AND NON-PALPABLE LIVERS IN 200 CHILDREN 5-9 YEARS OLD IN PALO (JULY-DECEMBER 1955)

	Age 5 years	Age 6 years	Age 7 years	Age 8 years	Age 9 years	Total
			Liver palpable			
Number examined	13	12	20	10	13	68
Mean Hb value and standard deviation (g per 100ml)	10.8 ±0.9	10.6 ±0.9	11.3 ±0.6	10.6 ±1.3	10.1 ±1.4	10.7 ±1.5
Mean eosinophil count and standard deviation (%)	28 ±8.2	22 ±11.3	21 ±9.6	28 ±5.6	23 ±10.8	22 ±9.5
			Liver not palpable			
Number examined	3	24	21	19	31	98
Mean Hb value and standard deviation (g per 100 ml)	11.2 ±0.7	11.0 ±0.8	10.9 ±1.7	11.0 ±1.3	11.2 ±2.0	11.1 ±1.7
Mean eosinophil count and standard deviation (%)	12 ±3.0	19 ±8.3	20 ±9.8	19 ±11.5	21 ±9.6	19.5 ±9.1

Attention should be paid here to the recent interest shown in the eosinophilia-hepatomegaly-anaemia syndrome met with among young children and caused by " visceral larva migrans ". Most paediatricians associate the condition with larvae of *Ascaris lumbricoides* and stress the possibility of a hyperergic reaction to *Ascaris* larvae or their products as the causative factor, and *Ascaris* larvae in the liver have been demonstrated (Mercer et al., 1950; Behrer, 1951). Others (Beaver et al., 1952; Milburn & Ernst, 1953) associate the condition with the *Ascaris* of the dog— *Toxocara canis* —and of the cat—*Toxocara cati (Toxocara mystax)*. In abnormal hosts the larvae have a pronounced tendency to wander extensively in various tissues without necessarily completing the entire life cycle (Wright, 1955). Attention should also be drawn to the role nematodes may play in producing endophthalmitis and blindness in children (Wilder, 1950).

Of the activities of children that bring them in contact with infected waters swimming and bathing are the most frequent, the next in importance being going to school, involving wading through infected waters. The practical importance of this information is that the provision of simple foot-bridges wherever necessary would eliminate one of the major sources of infection among schoolchildren.

Conclusions

It is not possible to draw any firm conclusions on the basis of this first round of examination, beyond a general indication as to further fields of investigation which may prove fruitful and lead to better understanding of the disease process among young children. The value of a concerted attack on the individual disease entity cannot be discounted, but to view all else in terms of that disease is to lose perspective of broader public health relationships. It is only on a clearer understanding of the whole disease situation that any outline of administrative action for permanent benefit can be based.

The Parasite Strain and Animal Hosts

The rationale of any control through attack on the parasite, either through sanitation or by treatment, will depend on the role which the reservoir hosts of *S. japonicum* play in the transmission of the disease. Since the discovery of the etiological agent in the domestic animals, a host of mammals have been added to the list of those that harbour the parasite, indistinguishable morphologically from the parasite of human origin, leading to the conclusion that the parasite has a wide choice of hosts in nature. The questions we therefore undertook to answer were:

1. Are there any strain differences between the parasites from the various mammals that would influence host selection in this area?

2. If the answer to the above is in the negative, then what is the relative role of the various reservoir hosts involved in the transmission of the disease?

We think we have satisfactorily answered these questions through the two studies reported here.

Analysis of possible strain differences of *S. japonicum* in Leyte

Early workers in bilharziasis japonica assumed that the parasite was the same in all vertebrate hosts, although minor local differences in egg-morphology were noted (Faust & Meleney, 1924; N. G. Hairston[a]). More recently, some significant biological differences have been discovered, the most important of which is the failure of the Formosa parasite to attack man. Hsu and colleagues (1955) and Dewitt (1954) found that parasites of different geographical origin varied in their ability to develop in different snail hosts, including the North American *P. lapidaria*. So far as we are aware, no attempt was made to discover if distinct strains existed in the same locality.

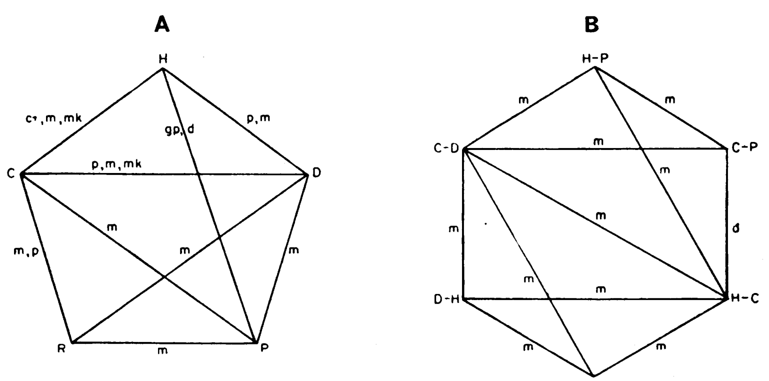
We have made a large series of experimental crosses of flukes, the origins

[a] Unpublished data, 1945

of which were five different mammal hosts—man, dog, pig, cow and rat—all naturally infected. Since sex is determined prior to the miracidium stage, a laboratory-hatched snail, infected with a single miracidium, yields cercariae of only one sex. The sex can be determined by experimental passage through laboratory animals; in routine practice, we use mice. As snail infections of the appropriate strains and sexes have become available, we have crossed flukes in a variety of experimental animals. The cross has been judged successful upon the appearance of eggs, either in the stool or in the gut wall at autopsy.

To date, all crosses of flukes of different origins have proved successful (Fig. 27A). Because miracidia are difficult to obtain from the stools of wild rats, and are frequently too weak to penetrate snails when they are obtained, we have not been able to complete crosses between flukes of rat and human origin. The nine different successful crosses obtained, however, indicate that non-human mammals do not carry strains distinct from the human in Leyte.

FIG. 27. SUCCESSFUL CROSS-INFECTIONS IN (A) PARENT CERCARIAE AND (B) F_1 CERCARIAE OF *S. JAPONICUM* FROM DIFFERENT HOSTS



In order to be doubly assured of the validity of this conclusion, we have tested the fertility of the hybrid flukes in a series of eleven crosses, as shown in Fig. 27B. In this series of experiments, we added the criterion of hatchability of the eggs obtained, in order to assure ourselves that the offspring of these hybrids were really viable. Again, all crosses attempted were successful, and there can be no further doubt that all Leyte schistosomes belong to a single strain.

In the light of these findings, control of bilharziasis in the Philippines would seem to involve more than sanitary disposal of human faeces, and an assessment of the relative role in transmission played by each species of definitive host therefore became of considerable importance.

Relative role of human and other animal reservoir hosts in transmission

An index that would express the relative importance of the different mammalian hosts would be a composite of several factors. These factors are the numerical strength of the host concerned, the proportion of the host population infected (prevalence of infection), and the miracidia-producing capacity of the host. The latter is dependent upon the average output and hatchability of eggs from the host. We therefore set out to determine all these factors for the seven mammals known to be involved in the transmission of *S. japonicum* in this area—humans, pigs, dogs, goats, carabaos (water buffaloes), cows and rats.

Materials and methods

In establishing the prevalence rates among the different mammals, the data obtained during the 1953-54 surveys were largely utilized, supplemented by enlarging the sample of carabaos, cows, horses, sheep, and goats examined. For the determination of the mean daily egg output, 53 humans, 23 pigs, 22 dogs, 1 carabao, 1 goat, 2 cows and 3 field rats were studied. Twenty-four-hour stools were collected and examined for five days from each animal, using the standard method.

Hatchability was determined using known numbers of ova in each case, and the production of miracidia was recorded for each sample. The percentage of hatchability was based on the totals.

In the case of the human host these rates were determined for the different age-groups into which the sample was distributed. Both the humans and the other mammals came from the different environments of Palo. Twenty-four-hour stools were collected from the homes of the persons examined. The animals were all kept at the project's animal house for the duration of the examinations.

Results

The prevalence rates among the different hosts in the pilot area were as follows:

Host	*Number examined*	*Number positive*	*Prevalence (%)*
Human	2909	1395	48.0
Dog	170	31	18.2
Pig	603	80	13.3
Carabao	137	2	1.5
Cow	34	13	38.2
Goat	69	1	1.4
Rat	203	46	22.7

Humans and cows have relatively high rates of prevalence; rats, dogs and pigs would fall into an intermediate category in the order named;

TABLE LX. RELATIVE TRANSMISSION INDEX OF DIFFERENT HOSTS OF *SCHISTOSOMA JAPONICUM* IN PALO

Host	Population	Prevalence (%)	Mean daily egg output	Hatchability (%)	Mean daily miracidia produced	Transmission index	Relative transmission index (% of total)
	A	B	C	D	C×D	(A×B)×(C×D)	$\frac{(A\times B)\times(C\times D)}{(\Sigma)}\times 100$
Human	14 819	48.0	1 123	42.4	476	3 385 845	75.7
Dog	1 517	18.2	13 106	17.8	2 333	644 127	14.4
Cow	76	38.2	12 212	71.9	8 780	254 901	5.7
Pig	3 193	13.3	481	31.9	153	64 974	1.5
Rat	148 190*	22.7	21	10.6	2	67 278	1.5
Carabao	1 318	1.5	9 166	29.4	2 695	53 280	1.2
Goat	204	1.4	952	71.4	680	1 942	0.04
						Total (Σ) 4 472 347	

* Estimated number of 10 rats per person, which equals 60 rats per hectare.

carabaos and goats have low rates of less than 3%. The carabao is the most important draft animal, and of the two animals found positive both were calves (not more 2 years old). The texture of the dermis in older carabaos perhaps makes penetration by cercariae difficult.

The highest mean daily egg output is from dogs and cows, with over 12 000 eggs, followed by the carabao with close to 10 000 eggs (Table LX). Humans and goats fall into an intermediate group; pigs and rats come last in the series. It is important to note that children in the age-group 10-14 years have nearly four times the production of eggs of any other age-group among the humans (Table LXI).

Hatchability from the different hosts bears no relation to either prevalence or the mean daily egg output. Cows and goats have the highest rates (over 70%) and dogs and rats the lowest (less than 20%). It is again interesting to note that children in 10-14 year age-group produce eggs which have the highest hatchability rate in comparison with eggs from other age-groups.

Table LX shows the stages in determining the index, which expresses the relative transmission potential for the different hosts, taking all the four factors involved into consideration. The relative transmission index, expressed as a percentage of the total role played by all the hosts involved for Palo, is:

Man	75.7%	Pig	1.5%
Dog	14.4%	Carabao . . .	1.2%
Cow	5.7%	Goat	0.04%
Rat	1.5%		

TABLE LXI. DAILY OUTPUT AND HATCHABILITY OF SCHISTOSOME EGGS IN HUMAN HOST BY AGE-GROUPS

Age-group (years)	Egg output				Hatchability		
	number of observations	mean eggs per 5 g of stool	mean daily stool weight (g)	mean 24-hour egg output	number of eggs used	number of eggs hatched	percentage of hatchable eggs
Below 10	12	27	68.5	370	240	96	40.0
10–14	48	130	166.1	4 318	1 961	950	48.4
15–19	20	36	160.6	1 156	264	98	37.1
20–29	48	17	154.6	547	697	252	36.2
30–39	33	16	166.8	533	480	165	34.4
40–49	19	25	146.6	733	352	166	47.2
50–59	12	11	138.6	304	95	33	34.7
60 and over	10	43	128.4	1 105	519	193	37.2
Total	202	48	151.8	1 521	4 608	1 953	42.4

Table LXII gives the relative transmission index of the different age-groups among humans. Almost 60% of the total infection from this source comes from the age-group 10-14, which constitutes 12.5% of the

TABLE LXII. RELATIVE BILHARZIASIS TRANSMISSION INDEX BY AGE-GROUP AMONG HUMANS IN PALO

Age-group (years)	Population	Prevalence of bilharziasis (%)	Positive population	Mean daily egg output	Hatchability %	Mean daily miracidia produced	Transmission index	Relative transmission index (% of total)
	A	B	A × B	C	D	C × D	(A × B) × (C × D)	$\frac{(A\times B)\times(C\times D)}{\Sigma}\times 100$
Below 10	4 331	18.2	788	370	40.0	148	116 624	3.0
10-14	1 852	59.9	1 109	4 318	48.4	2 090	2 317 810	59.9
15-19	1 648	66.6	1 098	1 156	37.1	429	471 042	12.2
20-29	2 219	65.9	1 452	547	36.2	198	289 476	7.5
30-39	1 621	57.3	929	533	34.4	183	170 007	4.4
40-49	1 280	60.2	771	733	47.2	346	266 766	6.9
50-59	904	49.4	447	304	34.7	105	46 935	1.2
60 and over	964	48.9	471	1 105	37.2	411	193 581	5.0
Total	14 819	48.0	7 113	1 521	42.4	645	(Σ) 3 872 241	100.0

total population in Palo. This segment of the human population not only bears the main stress of the disease, as shown earlier, but also plays the most important role in the transmission of the infection, and would therefore need the greatest medical and public health care in any bilharziasis control programme in this area.

It should be noted, however, that host for host, the cow and dog are much more important than man. Their relative efficiency, *not* taking population strength into consideration, is shown in the last column of Table LXIII. These figures illustrate the need for keeping a check on the cow and the dog population in the endemic areas in the Philippines.

TABLE LXIII. RELATIVE BILHARZIASIS TRANSMISSION INDEX OF DIFFERENT HOSTS ON THE BASIS OF EQUAL POPULATION (100 EACH)

Host	Population	Prevalence (%)	Mean daily egg output	Hatchability (%)	Mean daily miracidia produced	Transmission index	Relative transmission index (% of total)
	A	B	C	D	C × D	(A × B) × (C × D)	$\frac{(A\times B)\times(C\times D)}{\Sigma}\times 100$
Cow	100	32.2	12 212	71.9	8 780	335 396	82.2
Dog	100	18.2	13 106	17.8	2 333	42 461	10.4
Human	100	48.0	1 123	42.4	476	22 848	5.6
Carabao	100	1.5	9 166	29.4	2 695	4 043	1.1
Pig	100	13.3	481	31.9	153	2 035	0.5
Goat	100	1.4	952	71.4	680	952	0.2
Rat	100	22.7	21	10.6	2	45	0.01
						Total (Σ) 407 780	

Conclusions

Humans constitute the major source of infection and children in the age-group 10-14 form the most important section of the human reservoir from the public health point of view. In the light of these findings, the sanitary disposal of human faeces assumes greater importance and it becomes imperative to keep the cow and the dog population in check in the endemic areas. Other animal hosts seem to play a comparatively minor role in the transmission of *Schistosoma japonicum.*

Egg-laying Habits of *S. japonicum*

A working basis for the determination of the number of parasites in the human host exists in the case of *Ascaris* and *Ancylostoma* at least, but no such quantitative estimates have been possible in the case of schistosomes. This is mainly due to the habitat of the schistosome and to the fact that it has not been precisely known how many eggs a female *S. japonicum* lays, on the average, per day. We therefore set out to determine this.

Schistosoma japonicum is generally recognized as the most virulent of the three human blood-flukes (Faust & Meleney, 1924) for the reason that it produces a larger number of eggs than the other two species. Faust & Meleney (1924) also report having counted an average of 161 ova in flukes from young dogs. The more refined techniques introduced by Vogel (1942) have contributed greatly to our knowledge of *S. japonicum*, especially on the details of development of eggs after their deposition in the capillaries. Vogel & Minning (1947) determined an average of 124.5 eggs per female fluke from rabbits. In 1955, D. V. Moore and J. Sandground,[a] using hamsters as experimental hosts, have estimated that a female fluke lays 3500 eggs per day.

The fact that the egg is laid in the one-cell stage or very shortly thereafter and normally develops to the miracidium in about 10 days (Vogel, 1942) makes it possible to find all stages in the gut wall of an experimental host.

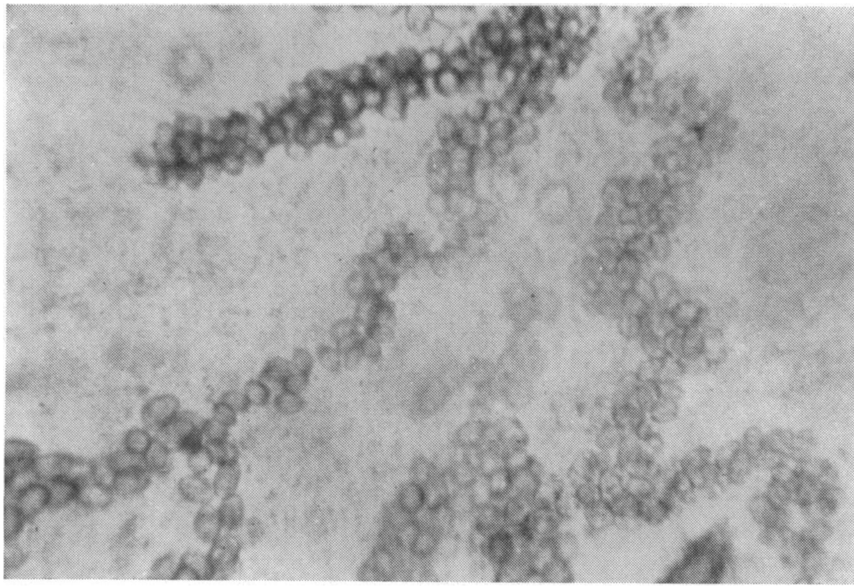
Materials and methods

In a small animal, such as a mouse, the gut is sufficiently thin for the eggs to be seen through a microscope in an undisturbed condition (Fig. 28). In these preparations, the eggs are always crowded together, and their mass reveals the branchings of the blood vessels in which they were laid. We refer to these masses of eggs as clusters. The eggs in a single cluster are always in the same stage of development, indicating that they were laid at the same time, probably by the same female. In old infections several stages may be found in a single mass of eggs; in such cases, the older eggs form a group in the smallest blood vessels, and eggs of decreasing age are in progressively larger vessels; this indicates a series of egg-layings at the same site. This interpretation seems to be logical, and we believe that it provides a technique whereby the egg-laying habits of the fluke can be determined in detail.

Our method was to infect mice with 2-5 cercariae of each sex. We used a modification of Dewitt's (1954) technique. We tied the mouse to a board instead of anaesthetizing it, picked up individual cercariae with a needle under a dissecting microscope and transferred them one by one to a small drop of water placed on a shaved area of the mouse's abdomen. The drop of water was then checked under the microscope to be sure that the cercariae had actually been transferred. This procedure resulted in a

[a] Unpublished data from the College of Medicine, New York University, N.Y.

FIG. 28. CLUSTERS OF EGGS IN WALL OF INTESTINE OF MOUSE *



* Darker eggs are younger.

recovery of 61 adult flukes out of 84 transferred—a rate of 72.6%. The mice were sacrificed at intervals of 1-4 days from the 22nd to the 46th day after infection. Each mouse was thoroughly examined for adult flukes, which were removed to physiological salt solution and examined under the microscope, where the ova in the uterus of each female were counted. The intestine was carefully removed and opened longitudinally. The intestinal contents were examined by the sedimentation and Faust & Meleney hatching techniques. The clean intestine was then cut into 4-cm sections, each of which was pressed gently between slides and examined under the microscope. The number of egg clusters and the number of eggs in each cluster were recorded as well as the stage of development of the eggs and the position of the clusters along the length of the gut. The liver, lungs and spleen were cut into slices, pressed between slides, and all eggs were counted.

Results

The detailed results are shown in Table LXIV. The data indicate that the beginning of egg-laying varied between the 23rd and the 27th day after infection, since on both occasions, we were able to demonstrate eggs in the uterus of female flukes and in the intestinal contents, but at neither time were we able to find any eggs in the gut wall. The presence

TABLE LXIV. EGG-LAYING OF *S. JAPONICUM* IN 17 MICE SACRIFICED AT VARYING INTERVALS OF INFECTION

Days	Number of female flukes	Total number of ova in uterus	Number of ova per female	Eggs in gut contents	Total eggs in stool	Number of egg clusters in gut wall	Total eggs in clusters	Total eggs in liver	Total eggs recovered	Average eggs per laying
22	1	0	0	0	0	0	0	0	0	0
23	2	9	4.5	8	0	0	0	0	0	0
25	2	44	22	0	3	2	38	565	606	303
26	1	32	32	1	0	3	102	350	453	151
27	1	0	0	0	0	0	0	0	0	0
27	2	3	1.5	2	2	0	0	0	2	2
28	1	3	3	0	0	0	0	5	5	5
29	2	30	15	0	0	28	1 379	288	1 667	59.5
32	2	206	103	0	0	116	8 018	955	8 976	78.4
34	1	61	61	0	0	47	3 094	925	4 019	85.5
34	2	77	38.5	0	0	83	6 352	3 419	9 771	117.7
38	2	199	99.5	0	3	240	23 918	**	23 921	99.7
39	4	432	108	0	4	506	52 179	**	52 183	103.1
39	3	**		0	6	603	62 810	**	62 816	104.2
41	1	8	8	9	6	231	22 504	3 308	25 827	111.8
42*	1	25	25	9	4	145	10 105	2 874	12 992	89.6
46	1	132	132	31	98	230	26 353	5 632	32 114	139.6

* Sex of cercaria given not controlled. ** Not recorded

of very young immature eggs (newly laid stage [a]) in the intestinal contents without any being found in the gut wall can only be accounted for in one of two ways: first, there may have been a rupture of the capillary into the lumen of the intestine at the time of egg-laying; secondly, in cutting open the intestine a cluster may have been cut, releasing the eggs into the gut contents. The data agree well with Vogel's observation that egg-laying starts at about the 25th day after infection. The most obvious discrepancies in the data are the large numbers of eggs per laying on the 25th and 26th days. We believe that in these instances the eggs were deposited into larger veins and carried directly into the liver without any clusters being left. Faust & Meleney observed similar phenomena. Aside from these two cases, it is interesting to note the similarities between the average number of eggs in the uterus of female flukes and the average number of eggs per laying. The obvious implication is that the female empties her uterus completely in a single act of egg-laying.

The figures in Table LXV also show that there is an increase in the rate of egg-laying for some time after the worms become sexually mature. We have rearranged the data to show this phenomenon more clearly.

FIG. 29. NUMBER OF EGG-CLUSTERS LAID PER FLUKE PER DAY*

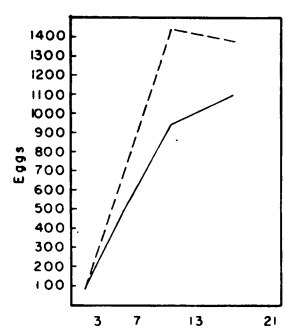
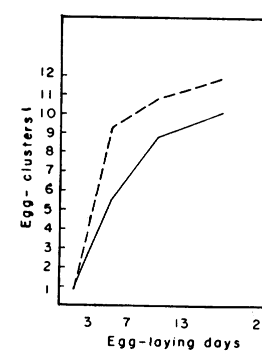


FIG. 30. NUMBER OF EGGS LAID PER FLUKE PER DAY*



* The broken line represents the calculated rate for the interval indicated and the solid line the average since the start of egg-laying.

Except for the two cases cited above, we have assumed that egg-laying started on the 25th day after infection. The data have been grouped so as to provide several cases for each time interval, and from these we have calculated the average number of egg-layings per day and the average number of eggs laid per day for the four time intervals. The results are shown graphically in Fig. 29 and 30. The direct averages reflect the rate of egg-

[a] N. G. Hairston, unpublished data

TABLE LXV. SUMMARY OF EGG-LAYING HABITS OF FLUKES IN MICE *

Range of egg-laying days	Average egg-laying days	Number of mice used	Number of female flukes	Total number of egg clusters	Number of egg clusters per fluke	Number of egg clusters per day since start of egg-laying	Calculated number of egg clusters per day of indicated interval	Total number of eggs laid	Number of eggs laid per fluke	Number of eggs laid by a fluke per day since start of egg-laying	Calculated number of eggs laid by a fluke per day of indicated interval	Number of eggs laid at one time
1–3	1.83	6	6	8	1.3	0.73	0.73	1 070	178	97	97	97**
4–7	5.5	2	4	144	36.0	6.5	9.4	10 640	2 660	484	676	72
9–13	10.3	3	4	370	92.5	9.0	11.8	37 910	9 478	921	1 420	120
14–21	17.0	5	10	1 715	171.5	10.1	11.8	186 364	18 636	1 096	1 367	116

* Not included are Mouse 94, which was autopsied on the 22nd day—earlier than any known egg-laying day—and Mouse 95, which contained only a male fluke.

** One female fluke that had laid no eggs up to the 27th day is omitted.

laying for the whole period from the 25th day to that on which the mouse was sacrificed. We have calculated the figure for each time interval by subtracting the observed number for the preceding intervals and considering the remainder as those actually laid during the span of days under consideration. The number of egg-layings per day rose from less than 1 during the first three days of mature life to nearly 12 after two weeks, and the number of eggs laid per day similarly rose from less than 100 to 1400 in the same period. This last number is less than half of Moore & Sandground's estimate. This is most likely due to the different hosts used, as *Schistosoma japonicum* is well known to develop differently in different hosts, the laboratory rat being the poorest mammal host known. It is also possible that Moore & Sandground used a strain of *S. japonicum* of Japanese or Chinese origin. The brief abstract of their work that is available to us does not state the strain used.

Summary

The eggs of *S. japonicum* are found in densely packed clusters in the gut wall of experimental animals. The eggs in a cluster are in the same stage of development, indicating that they are all laid at one time by one female, which probably empties her uterus in the act. Examination of mice sacrificed 22-46 days after infection has shown that both the frequency of egg-laying and the number of eggs laid at one time increase for a period of at least two weeks after the first eggs are laid. Counts of egg clusters in the gut wall and of eggs in these clusters and of those in the faeces, gut contents, liver and other organs show that 17 days after maturity a female fluke lays more than 100 eggs each time, 12 times a day.

RÉSUMÉ

La bilharziose à *Schistosoma japonicum* a été décrite pour la première fois aux Philippines en 1906. La découverte du vecteur en 1932 marque le début de la lutte. L'infection des troupes stationnées dans l'île de Leyte en 1944 donna un regain d'intérêt à ce problème. A la suite d'enquêtes qui en révélèrent l'étendue, un programme de lutte a été mis en œuvre en 1953 par le Gouvernement des Philippines, avec l'aide technique de l'OMS.

Les auteurs rendent compte des résultats des enquêtes épidémiologiques effectuées dans le cadre de ce programme. Les données fondamentale ont été recueillies dans la région de Palo et dans la zone contrôle contiguë de Tanauan. La prévalence y est de 48% et 46% respectivement, avec un maximum dans le groupe d'âge de 20-24 ans à Palo et de 10-14 ans à Tanauan. Les taux les plus élevés se rencontrent dans les villages, parmi les hommes et chez les fermiers. Une évaluation quantitative de l'infection a été tentée, ainsi qu'une classification par degrés d'infection, dans laquelle on a fait intervenir le facteur « incapacité de travail ». On a constaté que 62,5% des individus infectés ne présentent pas de symptômes cliniques. Parmi les cas cliniques, les formes bénignes prédominent, surtout dans les régions côtières. Ce sont les enfants de 10-14 ans qui paient le plus lourd tribut. Parmi les adultes, une tolérance à l'égard du parasite semble expliquer

la fréquence des formes asymptomatiques. Passé l'âge critique de 10-14 ans, les crises aiguës de la maladie sont rares. L'exposition fréquente à l'infection paraît susciter une immunité, qui a été confirmée expérimentalement chez le singe rhésus. Le nombre des cas nouveaux au cours d'une année a été estimé à 20,4%, par l'examen suivi de 200 enfants, négatifs au début de l'expérience. L'infection des enfants par d'autres parasites intestinaux empêche la délimitation exacte des troubles spécifiques dus aux schistosomes.

L'homme constitue la principale source d'infection; le chien et la vache jouent également un rôle à cet égard et il importe de maintenir leur nombre à un niveau raisonnable. Du point de vue de la santé publique, ce sont les enfants de 10-14 ans qui représentent le réservoir le plus important. *S. japonicum* est particulièrement redoutable du fait de sa fertilité. Le nombre d'œufs varie suivant l'hôte infesté. Chez la souris, les auteurs ont montré que, 17 jours après maturité, une femelle pond plus de 1200 œufs par jour.

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