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Intestinal parasitism in Malayan aborigines (Orang Asli)*

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Surveys were conducted in the southern Malay peninsula to assess intestinal parasitism in the aboriginal ethnic minority groups. Faecal specimens from 1 273 persons were examined by the thiomersal–iodine–formol direct-smear technique. Prevalences are reported and, for helminth infections, data on worm burdens. The state of sanitation in each of 9 cultural-ecological groups was assessed by means of a simplified system of scoring for variables. Particular attention was paid to relationships between cultural and ecological factors, sanitation, and observed patterns of intestinal parasitism. The author also discusses the fact that the number of parasitic species diminishes in habitats simplified by man, whereas an increase occurs in the prevalence and intensity of the more adaptable species that persist in ecosystems of low complexity.

The aborigines of Malaya are minority peoples who live in the closest possible association with the tropical forests of the lowlands and hills of the southern Malay peninsula. Their traditional modes of life reflect their adaptation to tropical forest ecosystems. Today many of these citizens of Malaya (West Malaysia) live outside the forest itself, but most of their villages are located close to the forest edge. Even though only about half of the aboriginal population (totalling some 46 000 in 1965, according to the official census of the Department of Aboriginal Affairs) remains within primary-forest areas, these are essentially forest people.

The forests that support them are not homogeneous. Many types of forest exist in the peninsula, reflecting differences in rainfall, topography, underlying rocks and soils, and altitude. Thus the contrasts in village habitats in various parts of Malaya are considerable, and now, after more than 100 years of intensive development accompanied by much forest clearance, they are even greater than in the past. Aboriginal villages are found not only in most types of primary forest below the altitude of 900 m but also in areas of secondary forest or scrub vegetation, usually near a surviving stand of primary forest, and also often near a rubber estate, a tin-mining pool, or even a large town. Together with this diversity in habitats there are many cultural differences between tribes, partly owing to the influence of more advanced communities, especially during the last three decades.

This diversity prompted the epidemiological study reported here. Surveys were conducted in 1962–64 to gather data on the prevalence and density of intestinal parasites with particular regard to ecological and cultural associations. A further reason for the investigation was that the Department of Aboriginal Affairs needed basic data on intestinal parasitism in aboriginal populations in order to proceed with clinical and preventive medical programmes on a rational basis (Bolton, 1968). In conjunction with this study the thiomersal–iodine–formol direct-smear (TIF-DS) technique of examining faecal specimens for the presence of intestinal parasites was evaluated as an epidemiological method. The results of this evaluation have already been reported in a methodological paper (Dunn, 1968a) that complements the present contribution.

THE MALAYAN ABORIGINES

In their study of the Malayan aborigines, Skeat & Blagden (1906) established three major ethnolinguistic divisions, which are still valid: Negrito (= Se-

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mang), Senoi (= Sakai), and Melayu Asli or aboriginal Malay (= Jakun or Proto-Malay). The languages and dialects of the two divisions first mentioned are considered to belong to the Austro-asiatic stock. Approximate centres of distribution of most of the larger aboriginal groups in Malaya are shown in Fig. 1.

Small populations of Negritos still survive as nomadic hunters, fishers, and " gatherers " or as semi-settled, part-time cultivators in southernmost Thailand and the northern interior of Malaya. About half a dozen territorial and ethnic subdivisions have been defined. Despite intermarriage with their Senoi neighbours, and the considerable cultural influence of the Senoi, the Negritos constitute a single, fairly homogeneous, ethnic group. The official figure for

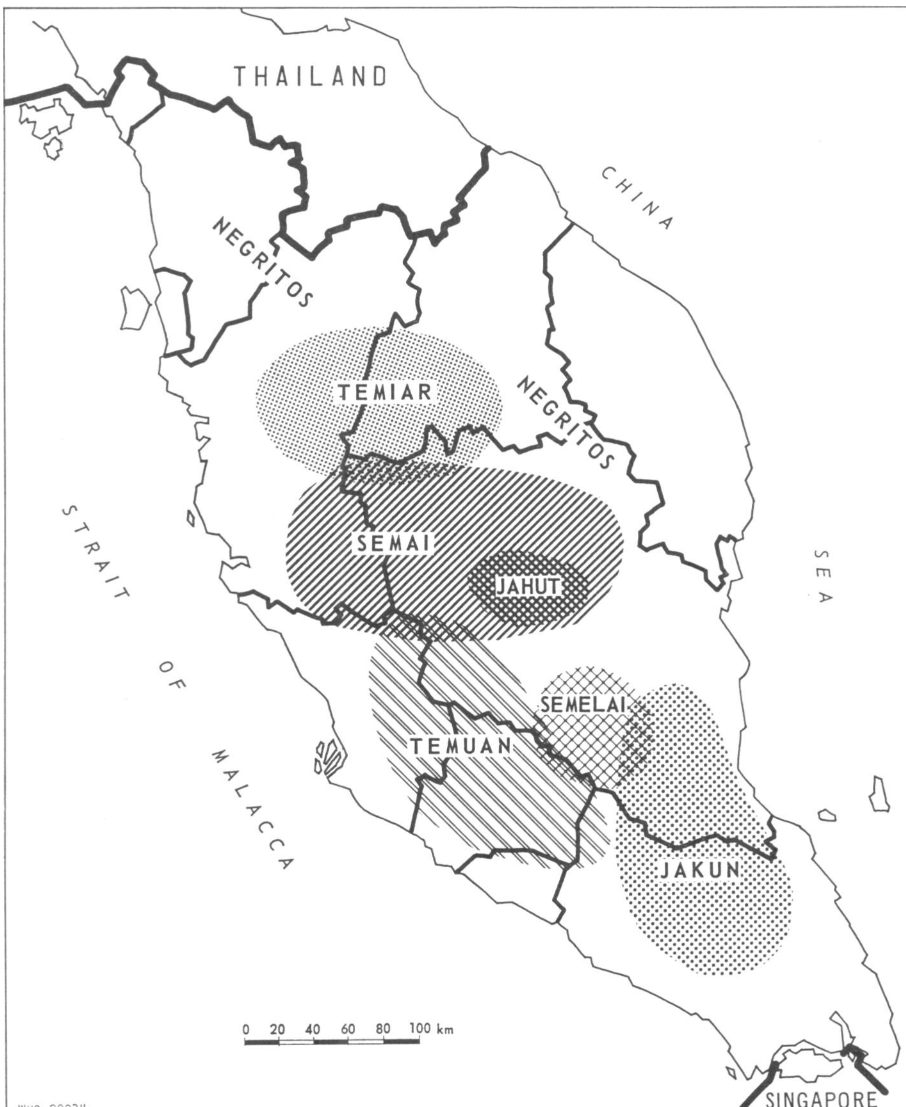

Fig. 1. Approximate centres of distribution of the larger aboriginal groups in the southern Malay peninsula.

the Negrito population in Malaya in 1965 was 1 447. Perhaps as many as 500 more live in the forests of southern Thailand.

Living entirely within West Malaysia, generally south and west of the Negrito areas, are the Senoi-speaking groups. The principal Senoi ethnolinguistic groups are: the Temiar, who officially numbered about 9 300 persons in 1965 and live mainly in the hills of the north; the Semai (about 12 750), broadly distributed throughout the hills and lowlands south of the Temiar area; the Jahut (about 1 900), the Che Wong (about 300), and the Semelai (about 1 400), in Pahang; and the Mah Meri (about 1 200), living along and near the southern and central Selangor coast.

The third main division of Malayan aborigines overlaps territorially, genetically, linguistically, and culturally with that of the Senoi. The two main ethnic groups are the Jakun, who numbered about 7 300 persons in 1965 and are distributed primarily in Pahang and Johore, and the Temuan (about 7 200) of Selangor, westernmost Pahang, Negri Sembilan, and Malacca. The Temuan, the Jakun, and a few other small but seemingly distinct ethnic groups (totalling about 1 600 persons in 1965) constitute the principal peninsular representatives of a larger body of forest people of the region comprising southern Malaya, eastern Sumatra, and the islands of the Malacca Straits. These people are animists and practise shifting cultivation. They all speak (or at one time spoke) languages belonging to the Malayo-Polynesian stock and closely related to the Malay language spoken today in southern and western Malaya. Some groups have lost their ethnic and linguistic identity since the beginning of this century.

MATERIALS AND METHODS

During the investigation, consisting of two hospital surveys and a series of field surveys, 1 273 persons, representing about 3% of the aboriginal population of Malaya, were examined for the presence of intestinal protozoa and helminths. These persons comprised the following: (*a*) 200 patients admitted consecutively to the Gombak Orang Asli Hospital, near Kuala Lumpur, for all causes (first hospital survey); (*b*) 237 consecutive, but selected, admissions to the same hospital (second hospital survey), only persons with signs or symptoms suggestive of intestinal parasitism being included (the patients in these two series represented all the principal ethnolinguistic groups in Malaya except Negritos); and (*c*) 836 villagers (86 Negritos, 542 Senoi, and 208 Melayu Asli) from whom specimens were collected on the spot (field surveys). Table 1 shows the ethnic identities of the 200 unselected patients and of the 836 villagers examined in the field surveys, as well as their means of subsistence and their habitats.

Faecal specimens from all 1 273 persons were collected and preserved in thiomersal–iodine–formol (TIF) following standard methods (Sapero & Lawless, 1953). The specimens were later examined by the TIF direct-smear technique (TIF-DS) (Dunn, 1968a). In order to determine the prevalence and the intensity of helminth infection, at least 2 TIF direct smears from 2–4-mg specimens were examined for each subject. The egg-counts were recorded, using the following score for worm burden: 1–2 eggs per smear (+), 3–19 eggs (++), 20–79 eggs (+++), 80 or more eggs (++++).

Survey counts [1] and efficiencies [2] were calculated according to procedures already outlined (Dunn, 1968a). For *Ascaris* the survey count was 4 020 eggs per g, corresponding to an efficiency of 90–95% in detecting all possible *Ascaris* infections; for *Trichuris*, 1 430 eggs per g, or an efficiency of 80–85%; and for hookworm, 1 010 eggs per g, or an efficiency of about 75%. The true prevalence of hookworm was substantially underestimated in virtually all the surveys even though the prevalence rates in the groups investigated are uniformly high. Very slight infections (1 egg per smear) were missed from time to time (as they also would have been with one of the dilution egg-counting methods). The extent of underestimation was about the same in all the surveys because prevalence rates, worm burdens, and survey counts were nearly comparable. In practice this underestimation is insignificant in an epidemiological study such as this, where relative frequencies are being compared. Since efficiency can be estimated with the aid of the survey count, a good approximation of the actual number of very slight infections missed can easily be calculated for any given survey. Efficiency in detecting intestinal protozoal infections cannot be measured in the same fashion, but complete scanning of two 22×22 mm smears at different magnifications is an effective way to recognize most such infections.

[1] The survey count is the mean helminth egg-count per g of faeces per person infected in a surveyed population.

[2] Efficiency, expressed as a percentage, denotes the effectiveness of faecal smear examinations in detecting all infections by a helminth species in a survey population.

Table 1. Ethnic group, means of subsistence, and habitat of Malayan aborigines examined for intestinal parasitism

No. examined: Field surveys [a] (total: 836)	No. examined: First hospital survey (total: 200)	Ethnic group	Means of subsistence	Habitat
74		Negrito	semi-nomadic hunting, gathering, fishing (HGF)	primary lowland forest (below 600 m)
12				
191		Temiar (Senoi)	shifting cultivation (also HGF)	primary hill forest (600–900 m)
	45			
45		Semai & Jahut (Senoi)		
	20	Semai (Senoi)		
83				primary lowland forest (below 600 m)
	50		mixed (casual labour, rubber tapping, shifting cultivation, HGF)	lowland secondary & primary forest
85				village outside forest near town, & Malay village
119		Semelai (Senoi)	shifting cultivation (also HGF)	lowland swamp forest (chiefly secondary) & swampy lakeside
19				
	21			
67		Jakun (Melayu Asli)		primary lowland swamp forest
	11			
75		Temuan (Melayu Asli)	mixed (casual labour, rubber tapping, shifting cultivation, HGF)	lowland secondary & primary forest
54				
12				
	53			

[a] Each figure represents the total number of persons examined in any one field survey.

GENERAL FINDINGS

Consolidated results

Table 2 summarizes the main findings of this investigation. Not including the pseudoparasite *Heterodera*, 22 species of helminth and protozoon were recorded as parasitic or probably parasitic in Malayan aborigines. Five of these stand out as particularly important in terms of potential pathogenicity and prevalence: *Entamoeba histolytica, Giardia lamblia, Ascaris lumbricoides, Trichuris trichiura,* and hookworm. In Malaya, hookworm infection in man

Table 2. Intestinal parasitism in Malayan aborigines: consolidated survey findings

Intestinal parasites	First hospital survey (200 unselected patients)		Second hospital survey (237 selected patients)		Field surveys (836 villagers)		All surveys (1 273 persons)	
	No.	%	No.	%	No.	%	No.	%
Intestinal protozoa								
Entamoeba histolytica	16	8.0	32	13.5	17	2.0	65	5.1
E. hartmanni	11	5.5	3	1.3	30	3.6	44	3.5
E. coli	53	26.5	66	27.9	239	28.6	358	28.1
Endolimax nana	18	9.0	17	7.2	44	5.3	79	6.2
Iodamoeba butschlii	6	3.0	3	1.3	26	3.1	35	2.8
Dientamoeba fragilis	1	0.5	—	—	2	0.2	3	0.2
Giardia lamblia	24	12.0	23	9.7	91	10.9	138	10.8
Chilomastix mesnili	4	2.0	4	1.7	19	2.3	27	2.1
" Small flagellates "	1	0.5	6	2.5	24	2.9	31	2.4
Trichomonas hominis	3	1.5	1	0.4	1	0.1	5	0.4
Balantidium coli	1	0.5	—	—	3	0.4	4	0.3
Isospora sp.	1	0.5	—	—	0	—	1	0.1
Major helminths								
Hookworm	144	72.0	120	50.6	610	73.0	874	68.7
+ [a]	80	(55.6) [b]	54	(45.0)	345	(56.6)	479	(54.8)
++	51	(35.4)	54	(45.0)	246	(40.3)	351	(40.2)
+++	13	(9.0)	11	(9.2)	19	(3.1)	43	(4.9)
++++	—	—	1	(0.8)	0	(—)	1	(0.1)
Ascaris lumbricoides	75	37.5	103	43.5	320	38.3	498	39.1
+	23	(30.7)	16	(15.5)	61	(19.1)	100	(20.1)
++	24	(32.0)	36	(35.0)	144	(45.0)	204	(41.0)
+++	20	(26.7)	40	(38.8)	87	(27.2)	147	(29.5)
++++	8	(10.7)	11	(10.7)	28	(8.8)	47	(9.4)
Trichuris trichiura	110	55.0	155	65.4	463	55.4	728	57.2
+	52	(47.3)	49	(31.6)	251	(54.2)	352	(48.4)
++	39	(35.5)	50	(32.3)	172	(37.2)	261	(35.9)
+++	16	(14.6)	41	(26.5)	36	(7.8)	93	(12.8)
++++	3	(2.7)	15	(9.7)	4	(0.9)	22	(3.0)
Persons negative for all intestinal parasites	8	4.0	30	12.7	73	8.7	111	8.7

[a] Worm burden scores based on TIF-DS egg-counts: + = very slight infection; ++++ = heavy infection.
[b] Figures in parentheses show percentages of infected persons at each level of worm burden.

is caused predominantly by *Necator americanus*. No attempt was made in these studies to determine the proportions of *Necator* and *Ancylostoma* infections. Two other nonpathogenic parasites—*Endolimax nana* and especially *Entamoeba coli*—were moderately prevalent. In addition to the parasites listed in Table 2, eggs or larvae of the following helminths were recorded in the surveys at very low rates of prevalence: *Enterobius vermicularis*, *Strongyloides stercoralis*, *Trichostrongylus* sp., an unknown larval nematode, two unknown trematode spp., *Taenia* sp., *Hymenolepis nana*, and *Heterodera* sp.

The study provides reasonably good estimates of prevalence for most species but not, of course, for *Enterobius vermicularis* or *Strongyloides stercoralis*. Pinworm surveys were not attempted. The culture of *Strongyloides* was not feasible under field conditions; although it would have been possible in the hospital surveys, it was omitted for lack of time. Among the rare species, *Balantidium coli* is of particular interest. This parasite had not been reported in man on the Malay peninsula before 1963, when a preliminary note on its occurrence was published (Dunn & Bolton, 1963), although it was on record that the parasite had been found in Chinese in Singapore (Desowitz et al., 1961). In 2 of the 4 cases *Balantidium* infection was associated—not necessarily causally—with dysentery. Three of these cases were recorded in Semelai from a village in central Pahang, which at the time was the only aboriginal locality where pig-rearing was practised. Thus *Balantidium* in Malayan aborigines may be regarded as an introduced infection. Possibly the infections in Semelai were acquired from their pigs, but the evidence for this suggestion is only circumstantial.

Parasitic species recorded for the first time in Malayan aborigines were: *Entamoeba hartmanni*, *E. coli*, *Endolimax nana*, *Iodamoeba butschlii*, *Dientamoeba fragilis*, *Giardia lamblia*, *Chilomastix mesnili*, *Trichomonas hominis*, *Balantidium coli*, *Isospora* sp., *Trichostrongylus* sp., unknown dicrocoelid trematode species No. 1, unknown trematode species No. 2, and *Hymenolepis nana*. The length of this list shows that very little attention has been devoted so far to parasitic infection, particularly protozoan, in Malayan tribal people. The eggs of two unknown trematodes posed a diagnostic problem, although the eggs of one at least can be recognized as those of a dicrocoelid. Only one parasitic species previously recorded in Malayan aborigines (Sandosham, 1954)—*Dipylidium caninum*—was not found in this investigation.

Discussion of consolidated results

It is noteworthy that the second hospital survey—covering a series of selected patients with symptoms suspected to be caused by intestinal parasites—revealed discrepancies in prevalence apparently related to this selection procedure. In comparison with the first hospital survey, in which unselected patients were examined, *Trichuris* was more frequent (by χ^2 test, $P < 0.05$) and *Entamoeba hartmanni* ($P < 0.02$) and hookworm ($P \leqslant 0.001$) were less so. *E. histolytica* and *Ascaris* appeared to be more frequent in the second hospital series, but the differences are not statistically significant. The rate for *E. histolytica* in the field surveys was significantly lower ($P \leqslant 0.001$) than that in the second hospital survey; the rates for *E. hartmanni* were not significantly different. The selection of patients in the second hospital survey apparently favoured the detection of parasites causing diarrhoea, dysentery, and abdominal pain. These differences in prevalence and intensity between surveys provide indirect evidence of the clinical patency and importance of the more intense *Ascaris* and *Trichuris* infections. The significantly higher proportion of patients not infected with any species of intestinal parasite in the second hospital survey than in the first ($P < 0.01$) reflects the examination of many parasite-free infants with diarrhoea.

Table 2 provides worm burden data of value in assessing the public health importance of the principal soil-transmitted helminths in Malayan aboriginal populations. The following scores and observations are relevant in evaluating these findings:

+ (1–2 eggs per 3-mg smear) = less than about 1 000 eggs per g of faeces:

++ (3–19 eggs) = about 1 000 to about 6 700 eggs per g;

+++ (20–79 eggs) = about 6 700 to about 26 700 eggs per g;

++++ (80 or more eggs) = more than about 26 700 eggs per g.

For *Ascaris*, the score of 20 000 eggs per g has been estimated to correspond to a " moderate " worm burden; for *Trichuris*, 20 000 eggs per g probably represents a " heavy " infection; for *Necator*, 6 600 and 10 200 eggs per g correspond to the detectable anaemia thresholds in males and females, respectively, according to one report (WHO Expert Committee on Helminthiases, 1964).

In each survey category about 10% of persons harbouring *Ascaris* shed more than 26 700 eggs per g (score: ++++); infections of this intensity are judged to be more than moderate. Indeed, many +++ *Ascaris* infections could be described as moderate or heavier. A considerable number of these aborigines clearly support heavy *Ascaris* burdens, and the infection constitutes an important public health problem. Terms such as " moderate " and " heavy " are, of course, clinically irrelevant in ascariasis since even a single worm poses a threat to the host.

The data in Table 2 suggest that *Trichuris* is not a general health problem since only 3% of all infections can be considered as heavy. However, as shown below, *Trichuris* varies highly in prevalence and intensity. In certain aboriginal communities it appears to be a significant cause of disease. Many cases of diarrhoea and dysentery in the second hospital series were also clearly associated with heavy (++++) *Trichuris* infections, which constituted 9.7% of all *Trichuris* infections in that survey.

Table 2 shows that, despite the high prevalence of hookworm, only about 5% of all infections recorded were sufficiently heavy to cause anaemia, if the threshold is taken to be a worm burden corresponding to 6 000–10 000 eggs per g. Although common, hookworm infection alone does not seem to be responsible for much disease. However, a few cases of severe anaemia in the second hospital series were associated with heavy hookworm burdens, and this highly prevalent infection is undoubtedly an important additive factor in anaemia and other states of ill health. Severe anaemia is rare in Malayan aborigines (only 10 of 237 patients were included in the second hospital series because of anaemia and suspected heavy hookworm infection), but marginal anaemia is common and is seemingly the product of a group of contributory factors (including hookworm and perhaps *Trichuris*) that vary in relative importance from one cultural-ecological setting to another (Polunin, 1953).

Parasitism in males and in females

The prevalence rates, for male and female hosts, of infection by the most common intestinal parasites have been summarized in Table 9.[1] In this table, data on the 200 unselected patients of the first hospital survey are combined with data on 737 of the 836 villagers examined in the field surveys (information on age and sex could not be obtained for some remote forest dwellers).

These consolidated findings show few differences in prevalence according to sex. *Entamoeba coli* is significantly more prevalent in females ($P < 0.01$); *Ascaris* and *Trichuris*, while differing little in prevalence between the sexes, tend to infect females somewhat more severely, but the difference is not statistically significant.

Parasitism according to age

Tables 10[1] and 11[1] present age-specific rates for seven age groups. All ages were recorded by Dr J. M. Bolton, Chief Medical Officer of the Department of Aboriginal Affairs, or by one of several trained aboriginal medical assistants. Ages recorded for persons born since the late 1940s are reasonably accurate; for those more than 20 years old, the estimated age may differ from the real age by 5–10 years. Thus only 10-year age groups are justified for persons aged more than 20 years.

Similar proportions of persons in all age groups were entirely free from intestinal parasitism at the time of examination. Neither the *Entamoeba histolytica* rates nor those for *E. hartmanni* differ significantly (by χ^2 test) between the seven age groups. *Endolimax nana* showed a pronounced upward trend in prevalence with increasing age. Unfortunately, little is known about the duration of *E. nana* infections in man. If such infections are long-lasting, *E. nana* can be regarded as a crude indicator of the degree and length of exposure to conditions of poor environmental hygiene. *E. coli* rates remain stable during the early and middle years of life, but rise somewhat in old age for no apparent reason. The *Giardia lamblia* curve differs strikingly: most children acquire infection at an early age; rates rise to a peak between the ages of 5 and 9 years and then fall sharply with increasing age (apparently rising again in old age).

The data gathered in this study show that the prevalence rates of the major soil-transmitted helminths in the villagers and unselected hospital patients examined resemble those reported elsewhere (WHO Expert Committee on Helminthiases, 1964). Hookworm is generally acquired later than *Ascaris* and *Trichuris*, but prevalence rates rise higher and remain at a plateau (higher than 70%) throughout life. In these aboriginal populations, as in others studied elsewhere, the highest prevalence rates occur between the ages of 10 and 30 years. The *Ascaris* age-specific curve is entirely different: infection is acquired early, and prevalence rates fall consistently with increasing age. The *Trichuris* curve is also

[1] Owing to lack of space, it has not been possible to include this table in the present article. However, copies are available, on request, from the Library, World Health Organization, 1211 Geneva 27, Switzerland.

distinctive: whipworm infection is acquired early, rates decline substantially after the age of 20, and particularly between the ages of 20 and 29 years, and rise again with old age.

Hookworm intensity as measured by egg output varies remarkably little from one age group to another. Egg output is not markedly lower in the 0–10-year span—a finding that is in accord with experimental findings in animals but not with certain other epidemiological studies of hookworm in man (WHO Expert Committee on Helminthiases, 1964). On the other hand, *Ascaris* and *Trichuris* worm burdens—as might have been expected—are substantially heavier in the early years of life.

Parasitism in infants

The data for infants aged 0–1 year were examined separately to determine the ages at which parasites are acquired. The combined surveys related to 33 infants of the following ages: 21 days (1), 2 months (2), 4 months (1), 5 months (2), 6 months (2), 7 months (1), 8 months (1), 9 months (1), 11 months (1), and " about 1 year " (21).

Of these infants, 15 were free from all parasites; 10 (30%) harboured *Trichuris*; 12 (36%), *Ascaris*; and only 4 (12%), hookworm. Other parasites included *Giardia* (in 3 infants); " small flagellates " —probably *Embadomonas*—(in 1); *Entamoeba coli* (in 1); and eggs of *Trichostrongylus* sp. (in 1). The age of the youngest infant harbouring each species was: 6 months for hookworm and *Giardia*, 5 months for *Ascaris*, and " about 1 year " for *Trichuris*, *E. coli*, small flagellates, and *Trichostrongylus*.

THE FIRST HOSPITAL SURVEY: AN ENVIRONMENTAL COMPARISON

The initial survey of 200 patients admitted consecutively to hospital for all cause provided an early opportunity to compare parasitism in Malayan aborigines—those who have left their traditional forest environment, on the one hand, and those who are still forest dwellers and subsistence cultivators on the other. Dr Bolton independently classified each of these 200 patients as " inside " (meaning forest-dwelling, traditional agriculturists) or " outside " (meaning those living outside the forest or close to a town who are more or less involved in the cash economy and more or less divorced from the traditional shifting cultivation).

Table 3 presents data in terms of these simple categories. It reveals differences in pattern that appear

Table 3. The first hospital survey: an environmental comparison of patients living " inside " and " outside " the forest [a]

Data	" Inside " (64 patients)		" Outside " (136 patients)	
	No.	%	No.	%
Males	43		88	
Females	21		48	
Negative for all parasites	4		4	
With symptoms suggesting intestinal parasitism	2	3.1	31	22.8
E. histolytica	2	3.1	14	10.3
E. hartmanni	1	1.6	10	7.4
E. coli	17	26.6	35	25.7
E. nana	4	6.3	14	10.3
G. lamblia	6	9.4	18	13.2
Hookworm	52	81.3	92	67.7
Ascaris	6	9.4	69	50.7
Trichuris	13	20.3	97	71.3

[a] See text for an explanation of " inside " and " outside " in this context.

to be associated with environmental and cultural differences between the two groups—given equal proportions of males and females, similar ages (not included in the table), and a relatively homogeneous genetic background. Only 33 of these 200 patients presented symptoms suggestive of intestinal parasitism, yet 31 of these 33 were " outsiders ". This is consistent with significantly higher prevalence rates for *Ascaris* ($P \ll 0.001$), *Trichuris* ($P \ll 0.001$), and *Entamoeba histolytica* ($P < 0.05$) in the " outside " group. Hookworm is significantly more prevalent " inside " ($P < 0.05$). *Entamoeba coli* is about equally prevalent in both groups, and the rates for *E. hartmanni*, *Endolimax nana*, and *Giardia lamblia* do not differ significantly. Egg-count scoring for soil-transmitted helminths was also revealing: hookworm burdens were roughly similar in the two groups but *Ascaris* and *Trichuris* burdens were far heavier in the " outsiders ".

This preliminary comparison provided the stimulus for a further investigation (described in the next section) into the distribution of parasites among these aborigines.

CULTURAL-ECOLOGICAL GROUPS, SANITATION, AND INTESTINAL PARASITISM

The ethnic groups listed in Table 1 are rearranged and more fully characterized in Table 4. The tabulated data are self-explanatory except for the category " Sanitary status (and score) ". The descriptive scale used for sanitary status is: *good*, *fairly good*, *fair*, *fairly poor*, and *poor*. No *good* or better sanitary conditions were observed in the aboriginal villages visited during the field surveys. Latrines, or other receptacles for faeces, such as buckets, were not used in any of the surveyed communities. Semiquantitative scores for sanitary status are also given.

The sanitary assessments in Table 4 were reached after the following factors had been considered:

(1) Excreta and rubbish disposal practices do not appear to differ strikingly from one ethnic group or community to another. In all groups, defecation by very young children (toddlers) is relatively "promiscuous"—that is, the child may defected close to or under the house, or at least within the village confines. However, even young children are discouraged from defecating in village streams whose water may be used for drinking and bathing. Yet this prohibition does not prevent the contamination of village water sources with faecal material because children often cleanse themselves after defecation, deliberately or inadvertently, while playing in village streams. Older children and adults are more secretive about defecation and usually leave the village area for that purpose.

As far as these aboriginal communities are concerned, contamination by defecation may be visualized as a series of concentric zones (this generalization is based on observations in Temuan, Semai, Temiar, and Semelai communities). At the centre, contamination is largely caused by toddlers, who

Table 4. Living conditions in nine cultural-ecological groups of Malayan aborigines

Ethnic group	No. examined	Habitat	Mobility	Means of subsistence	Housing	Sanitary status (and score) [a]
Negrito	86	primary lowland forest (below 600 m)	semi-nomadic	hunting, gathering, fishing (HGF)	temporary shelters on the ground (slightly elevated sleeping platforms)	fairly good (30)
Temiar	236	primary hill forest (600–900 m)	occasional residence shifts	shifting cultivation and HGF	substantial houses on piles (some longhouses)	fairly good (30)
Semai and Jahut	65	"	"	"	single- or double-room houses on piles	fairly good (28)
Semai	83	primary lowland forest (below 600 m)	"	"	"	fair (27)
	50	lowland secondary and primary forest	semi-permanent settlements	mixed (casual labour, rubber tapping, shifting cultivation, HGF)	single- or double-room houses of poorer quality on piles	fairly poor (20)
	85	squatter village outside forest near town, and Malay village	permanent settlement	"	usually double-room houses of poorer quality on piles (some plank floors)	poor (12)
Jakun	78	primary lowland swamp forest	occasional residence shifts	shifting cultivation and HGF	usually single-room houses on piles	fair (26)
Semelai	159	lowland swamp forest (chiefly secondary) and swampy lakeside	semi-permanent settlements	shifting cultivation, pig-rearing, HGF	usually double-room houses on piles	fairly poor (19)
Temuan	194	lowland secondary and primary forest	semi-permanent settlements	mixed (casual labour, rubber tapping, shifting cultivation, HGF)	usually double-room houses of poorer quality on piles	fairly poor (17)

[a] See page 109 for an explanation of the method of establishing scores for sanitary status.

usually defecate near or under their homes; older persons rarely do so. The scrub, and village orchards and back gardens constitute a second zone favoured for defecation by older children, especially males. Adults only infrequently use these areas close to the village centre. Still farther out, the zone of gardens and fields is favoured for defecation by females, especially adults and adolescents. Adolescent and adult males may also resort to cultivated areas for defecation, but more often they do so at the forest fringe or in the outermost zone, the forest itself. Thus environmental contamination with human faeces occurs in zones according to age and sex. Contamination is most pronounced at the centre, around and under houses, where toddlers are concentrated in a relatively small area. It is lowest in the wider peripheral zones—the cultivated areas and especially the forest. Those who use these areas disperse their faeces, thus inadvertently minimizing the chances that any helminth eggs that may be passed will reach new human hosts.

Rubbish disposal is casual in all Malayan aboriginal populations. Household refuse falls or is thrown to the ground under or around the house. Although house sweeping is a common practice, sweeping the earth under and around the house is less frequent. Plank-floored houses present special problems because refuse that would fall through the gaps in a floor made of split bamboo or other stems may accumulate within the house.

(2) Although sanitary behaviour appears to be similar in all communities, certain environmental and cultural variables interact with customary behaviour to produce different sanitary conditions. These variables include:

Population density and crowding. Communities with large populations crowded into small areas will suffer more intense environmental contamination by defecation in a given span of time than will communities with small and widely dispersed populations. One Semai village outside the forest and near a town provides a striking example of this effect. In this village, refuse and children's faeces were abundantly scattered about. The casual visitor could readily see that the environment of this densely populated village would be heavily contaminated; this contrasted with the impression of relative cleanliness in many highland Temiar villages.

Land availability around the village. The sanitary status of a village is less likely to be poor if it is surrounded by forest and ample land for cultivation, as in the Temiar communities. Under such conditions defecation is well dispersed and soil contamination is minimized. At the other extreme, the Semai village near a town is virtually a squatter community wedged in between a highway, a Malay village, and barren tin-mining wasteland (with little screening vegetation). Here defecation cannot be naturally dispersed and contamination of the village area is inevitably intense.

Community mobility. In the semi-nomadic Negrito way of life, with frequent abandonment of dwellings and new dwelling construction in " clean " locations, the contaminated environment—soil, refuse accumulations, water supply—is often left behind. At the other extreme, those aborigines who live in permanent settlements never escape the contamination of their surroundings—a contamination that can only become worse until it reaches a climax level and stabilizes.

Agricultural subsistence v. hunting, gathering, and fishing. The degree of contact with the soil is another determinant of sanitary conditions in a community. Negrito populations that subsist without agriculture have much less contact with potentially contaminated soil in the areas around their villages. Agriculturists (other than those who produce only tree crops) are regularly exposed to any pathogens that the soil may harbour.

Ground-level v. pile-elevated housing. Most Negritos live on or close to the ground in shelters that may be occupied for only a few weeks. Their daily contact with the soil in the vicinity of their homes must be substantially greater than that of any other aboriginal group in Malaya. The pile dwelling offers many advantages in the tropics, not the least of which is elevation of the living surface above the contaminated surroundings of the house.

Domestic animals that may ingest refuse and faecal matter within the village area. Pigs, dogs, and other domestic animals, when present in large numbers, can play a significant role as scavengers in reducing environmental contamination within a village.

Environmental factors affecting the viability of helminth eggs and larvae in the soil. The Temiar (and some Semai and Jahut), living at cooler, higher elevations than other groups, may suffer less from soil-transmitted helminthiases because the type of soil and the low temperatures in those regions may adversely affect the viability of helminth eggs. In some warmer lowland areas, on the other hand, soil

Table 5. Scoring form for the semiquantitative assessment of sanitary conditions in Malayan aboriginal communities

Variables affecting sanitary status	Score (from 1 to 5) for each variable				
Intravillage population density	high 1	2	intermediate 3	4	low 5
Village population size	high 1	2	intermediate 3	4	low 5
Land availability around village	little or none 1	limited 2	intermediate 3	4	abundant 5
Community mobility	none 1	low 2	intermediate 3	4	high 5
Agriculture versus hunting, gathering, & fishing (HGF)	fully agricultural 1	25 % HGF 2	50 % HGF 3	75 % HGF 4	100 % HGF 5
Ground-level housing versus pile dwellings	ground 1	low posts 2	low piles 3	medium piles 4	high piles
Domestic animals that may scavenge refuse (pigs, dogs, etc.)	absent 1	few 2	intermediate 3	4	many 5
Environmental factors affecting viability of helminth eggs and larvae (altitude, humidity, temperature, soil type, etc.)	all favourable for parasites 1	2	intermediate 3	4	all unfavourable 5

conditions are optimum for the transmission of hookworm, whipworm, and *Ascaris*.

The variables described above were used in making a semiquantitative assessment of the sanitary conditions in aboriginal communities by means of the scoring form in Table 5. This permits a score (from 1 to 5) to be assigned to a particular community for each of 8 variables affecting the sanitary status. The total of these 8 variable scores (which must lie between 8 and 40) is the " sanitary score " for that community. With the information provided by this score a descriptive sanitary status can be assigned to each community on the following basis: *poor* (scores from 8 to 13), *fairly poor* (14-20), *fair* (21-27), *fairly good* (28-34), *good* (35-40). The sanitary status shown in Table 4 can then be related to the prevalence rates for 8 intestinal parasites (Table 6) and to estimates of the intensity of helminth infection (worm burden) (Table 7).

Tables 6 and 7 show the distribution of intestinal parasites in terms of prevalence and intensity. In the Temiar, for example, *Ascaris* is almost absent, *Trichuris* is relatively rare (and the few infections are light), whereas hookworm is highly prevalent, with worm burdens comparable to those in most of the other ethnic groups studied. The main intestinal protozoa are of low to very low prevalence. In the Negrito group, also of the northern Malayan forest, the pattern differs somewhat: hookworm infection is almost universal and worm burdens are heavier than in any other Malayan aboriginal population. *Trichuris* ($P \ll 0.001$), *Ascaris* ($P < 0.001$), *Entamoeba coli* ($P < 0.02$), and *Giardia lamblia* ($P < 0.02$) are significantly more prevalent than among the Temiar.

The differences in intestinal parasitism between the Negrito and Temiar groups cannot be ascribed merely to differences in sanitary status (Table 4 shows this to be similar in the two groups) or in behaviour related to the disposal of faeces and rubbish. However, certain variables affecting sanitary status differ substantially between the two groups: housing, mobility of the community, means of subsistence, and habitats. Thus the observed differences in the distribution of parasites are almost certainly associated

Table 6. Parasite prevalence rates for nine cultural-ecological groups of Malayan aborigines

Group	No. examined	Negative (%)	Proportion infected (%)							
			E. histolytica	*E. hartmanni*	*E. coli*	*E. nana*	*G. lamblia*	Hookworm	*Ascaris*	*Trichuris*
Negrito	86	3.5	1.2	1.2	30.2	5.8	9.3	93.0	11.6	55.8
Temiar	236	15.7	0.8	0.4	17.8	2.1	3.0	77.6	2.1	23.3
Semai & Jahut	65	16.9	1.5	—	27.7	6.2	7.7	52.3	20.0	29.2
Semai	83	14.5	6.0	4.8	38.6	3.6	9.6	73.5	13.3	12.1
	50	4.0	16.0	2.0	38.0	16.0	20.0	66.0	58.0	60.0
	85	1.2	4.7	14.1	38.8	4.7	49.5	57.6	56.5	83.5
Jakun	78	7.7	—	1.3	30.8	2.6	2.6	64.1	65.4	61.6
Semelai	159	3.8	0.6	3.1	17.0	5.0	5.7	69.9	71.0	72.3
Temuan	194	1.5	5.7	7.7	36.6	11.9	12.4	78.9	59.3	91.3
Total No. examined & average proportions infected	1 036	7.8	3.2	4.0	28.2	6.0	11.1	72.8	38.1	55.4

Table 7. Intensity of helminth infection (worm burden) in nine cultural-ecological groups of Malayan aborigines

Group	No. examined	Proportion infected (%)										
		Hookworm			*Ascaris*				*Trichuris*			
		Egg-count score			Egg-count score				Egg-count score			
		+	++	+++	+	++	+++	++++	+	++	+++	++++
Negrito	86	31.3	63.7	5.0	40.0	60.0			85.5	14.5		
Temiar	236	54.1	42.6	3.3	100.0				80.0	12.7	7.3	
Semai & Jahut	65	55.9	41.2	2.9	54.8	7.7	23.1	15.4	79.0	21.0		
Semai	83	72.2	27.8		27.3	45.4	27.3		100.0			
	50	48.5	42.5	9.0	24.1	34.5	27.6	13.8	40.0	40.0	16.7	3.3
	85	75.5	20.4	4.1	12.5	47.9	27.1	12.5	53.5	42.3	4.2	
Jakun	78	46.0	46.0	8.0	9.8	58.8	27.5	3.9	52.1	45.8	2.1	
Semelai	159	64.9	31.5	3.6	15.9	46.0	31.0	7.1	67.8	31.3	0.9	
Temuan	194	58.8	36.0	5.2	25.2	35.7	26.9	12.2	21.4	54.3	20.9	3.4
Total No. examined & average scores	1 036	56.4	39.4	4.2	21.3	42.5	27.1	9.1	53.0	36.8	9.1	1.1

with differences in one or more (or all) of these four variables. However, the data at hand do not show which is the most important in accounting for a particular difference in parasitism between the Negrito and Temiar groups. These cultural–ecological comparisons narrow the range of possible causal associations, but a detailed epidemiological investigation would be necessary to explain these differences as well as others shown in the tables.

Another example of contrasts in the distribution pattern of intestinal parasites is that between the Temiar and the 85 Semai examined in a village outside the forest, near a town. Their scores for sanitary status differ greatly: fairly good (30) for the Temiar and poor (12) for the Semai. Most of the sanitary variables that have been discussed differ profoundly between these two groups, reflecting strikingly different sanitary conditions. In this comparison of conditions " inside " and " outside " the forest we have a refined version of the crude comparison between " inside " and " outside " patients described earlier (see page 106) and summarized in Table 3. The prevalence rates for all intestinal protozoa are substantially higher in the Semai squatter village, and the rate for *Giardia lamblia* is one of the highest on record for this agent. *Entamoeba histolytica* ($P<0.05$) and *E. hartmanni* ($P \leqslant 0.001$) are much more prevalent in the squatter community. *Ascaris* ($P \leqslant 0.001$) and *Trichuris* ($P \leqslant 0.001$) rates also are higher, and worm burdens heavier, in the squatter population. However, hookworm is significantly more prevalent ($P<0.001$) in the Temiar, who also suffer from a heavier worm burden than the squatter Semai.

These contrasts reflect the effects, on intestinal parasitism in a human population, of a rather recent change in the way of life. The Semai of this squatter settlement left their traditional forest life after the 1940s. Thus the differences in the prevalence and intensity of infection between them and the Temiar are measures of the disease burden that was imposed upon the Semai population as it experienced ecological displacement and the influence of cultures that are more advanced technologically.

ECOLOGICAL COMPLEXITY, DIVERSITY, AND NUMBER OF SPECIES OF INTESTINAL PARASITES

As has been noted elsewhere (Dunn, 1968b), the principles of ecological diversity and complexity apply to both parasitic and nonparasitic organisms. The number of species of parasite in man is closely related to the complexity of the ecosystem of which he is an element. Thus, one would expect that Negritos subsisting on hunting, fishing, and gathering in the complex ecosystem of the Malayan rain forest —and who therefore do not significantly modify their habitat—would be subject to a greater variety of parasites than those aborigines who have drastically simplified their surroundings in preparing land for settlement and cultivation. In support of this hypothesis, Table 8 presents data on the numbers of parasitic protozoan and helminth species found in the aborigines examined during the course of the field surveys. The Negritos harboured more species of intestinal parasite than any other ethnic group studied. Of the groups listed in Table 8, only the Negritos subsist in the forest without modifying it. When the tropical forest ecosystem is simplified by man, some species of intestinal organism are eliminated as potential parasites of human beings. They are insufficiently adaptable to such simplified habitats—i.e., their natural cycles of transmission are disrupted by simplification. Thus parasites that require intermediate hosts in addition to the human host are the most susceptible to elimination as man clears and cuts back the forest. In this study, several such parasites—*Hymenolepis nana* and two unidentified species of trematode—were detected only in people of the primary forests. Yet some of the more adaptable parasites, such as *Ascaris*, *Trichuris*, *Giardia*, and *Entamoeba histolytica*, could be likened to weeds. Although they infect forest people, they are much more successful, in terms of prevalence and intensity, in simplified habitats. They are most successful of all in the ultimate simplification of the Semai squatter village.

Table 8. Numbers of species of intestinal protozoa and helminths found in various ethnic groups of Malayan aborigines

Ethnic group	No. examined	No. of protozoan species	No. of helminth species	Total No. of species
Negrito	86	9	9	18
Temiar	191	7	5	12
Semai & Jahut	45	5	6	11
Semai	83	8	4	12
	85	8	4	12
Jakun	67	6	5	11
Semelai	138	10 [a]	4	14 [a]
Temuan	75	8	6	14
	54	7	3	10
	12	3	3	6

[a] Includes an introduced parasite, *Balantidium coli*, not found in other Malayan aborigines.

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RÉSUMÉ

PARASITISME INTESTINAL CHEZ DES ABORIGÈNES MALAIS (ORANG ASLI)

On a mené en 1962/64 des enquêtes sur le parasitisme intestinal parmi les Orang Asli, groupe ethnique minoritaire du sud de la péninsule malaise. Cette étude était motivée par l'absence quasi complète de données sur la prévalence des infestations par les helminthes et les protozoaires chez ces aborigènes par ailleurs remarquables par la diversité de leurs conditions culturelles et écologiques.

Un examen direct des fèces conservées dans une solution de thiomersal-iode-formol a été effectué chez 1273 personnes, dont 437 sujets hospitalisés et 836 villageois. Vingt-deux espèces d'helminthes et de protozoaires, parasites ou probablement parasites, ont été identifiées, cinq d'entre elles (*Entamoeba histolytica*, *Giardia lamblia*, *Ascaris lumbricoides*, *Trichuris trichiura*, ankylostome) présentant une importance particulière en raison de leur pathogénicité potentielle et de leur fréquence.

On a constaté une plus forte prévalence des infestations et une charge parasitaire plus élevée chez les indigènes ayant abandonné leur milieu traditionnel. Cependant l'ankylostomiase et le parasitisme à *Entamoeba coli* étaient également fréquents dans tous les groupes étudiés. Certaines populations offrant une gamme de caractéristiques culturelles et écologiques ont fait l'objet d'une enquête plus approfondie, dont les résultats, analysés et présentés sous forme de tableaux, font ressortir des variations considérables du parasitisme intestinal. Un fait remarquable est l'existence d'un plus grand nombre d'espèces parasitaires chez les Négritos, groupe vivant en forêt et s'adonnant à la chasse, à la pêche et à la cueillette des fruits, que dans d'autres populations vivant dans un milieu qu'elles ont entrepris de modifier et où certaines espèces de parasites ne peuvent subsister.

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