SOME EPIDEMIOLOGICAL ASPECTS OF HOOKWORM INFECTION AMONG THE RURAL POPULATION OF BALI, INDONESIA

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Abstract. Stool examination using direct smear method, Kato-Katz thick smear technique and modified Harada Mori test tube cultivation method were done on 2,331 people among the rural population of Bali. The serum ferritin was examined by ELISA technique and hemoglobin concentration by cyanmethemoglobin technique. Overall prevalence of hookworm infection was 24.02% with heterogeneity in local prevalences. The highest prevalence was found in wet highland area (46.3%), followed by wet lowland (27.7%), dry highland (14.2%) and dry lowland (10.9%). The majority of hookworm infection cases were associated with *Ascaris* and *Trichuris* infections. Most of the hookworm infections (73.3%) were light/very light in intensity with a mean EPG of 619. The prevalence and intensity of infection were increasing with age, and the age-prevalence and age-intensity curves were slightly convex. There was no significant difference of prevalence or intensity of infection between males and females. The condition and humidity of soil found to be an important determinant for prevalence of hook-worm infection. The frequency distribution of the intensity of hookworm infection showed an over-dispersed distribution pattern with 10% of people harboring more than 63% of parasite burden as measured by EPG. The prevalence of anemia was higher, but not stastically significant, in hookworm infected persons compared with people without infection. But this study failed to show a significant correlation between intensity of infection with hemoglobin level. There was a significant correlation between serum ferritin level with intensity of infection.

INTRODUCTION

Hookworm infection is widely prevalent, particularly in tropical and subtropical countries. It was estimated that more than one quarter of the world's population have been affected (Stoll, 1962). Bali, one of the smallest provinces of Indonesia, lies entirely in the tropical zone. Most of its population live as traditional agriculturists in rural areas. The hygiene and sanitation conditions are generally poor with more than 75% households having no latrines (Suryadhi *et al,* 1982). Many other factors contribute to the high prevalence of hookworm infection such as type of soil, amount of rainfall, and sociobehavioral variables. The prevalence of hookworm infection in Bali was reported to vary between 19.2% and 72.5% (Sutisna, 1989). This great variation may be due to difference in sample selection, age of the sample and location of the survey.

Hookworm infections are closely implicated in the etiology of iron deficiency anemia (Woodruff, 1982). It is estimated that 50,000 deaths per year occur worldwide as a result of hookworm infection (Walden, 1991). Various other nutritional deficiencies including protein, folic acid and vitamin B 12, have also been reported in individuals with hookworm infection (Li, 1990).

Regarding its high prevalence and the consequent effects on health, hookworm infection has become an important public health problem in Indonesia, which needs an appropriate control strategy. This survey is a cross sectional study on hookworm infection in the rural population of Bali, aimed to assess some epidemiological factors such as prevalence and the influence of sex, age and type of area on prevalence and intensity of the infection.

MATERIALS AND METHODS

This study was conducted in four villages representing variation of geographical conditions of the region of Bali, namely wet lowland, wet highland, dry highland and dry lowland. (1) The village of Belumbang in the subdistrict of Kerambitan represents the wet lowland. It lies 25 km west of Denpasar, the capital of Bali, with an elevation of 0-200 meters above sea level. The ecosystem basis of the area is ricefield which is well irrigated all year round, and the type of soil is yellowish latosol. The average annual rainfall is 1,726 mm with 7 months of wet season and one month of dry season. (2) The village of Baturiti in the subdistrict of

Baturiti represents the wet highland. It lies 50 km north of Denpasar, with an elevation of between 500 to 1,000 m above sea level. Its ecosystem basis is mostly ricefield. The type of soil is grey brown andosol. The average annual rainfall is 2,857 mm with 6 months of wet season and 0 month of dry season. (3) The village of Kubutambahan, which represents the dry lowland, lies 100 km north of Denpasar at 0 to 500 m above sea level. The ecosystem basis is fieldcrops, but not ricefields. The type of soil is brown regosol; the average annual rainfall is 980 mm with 4 months of wet season and 4 months of dry season. (4) The village of Batur in the subdistrict of Kintamani represents the dry highland. It lies 70 km northeast of Denpasar at 1,000 m above sea level. The ecosystem basis is fieldcrops with no ricefields. The type of soil is humic regosol; its average annual rainfall is 1,129 mm with 6 months of wet season and 5 months of dry season.

Selection of samples was done by multistage sampling technique, based on age and type of area. The number of population samples needed was 2,880 persons.

Hookworm infection was determined by direct smear method, Kato-Katz thick smear method and Harada-Mori test-tube cultivation method as modified by Kosin *et al* (1973). Hemoglobin concentration from venous blood was determined using cyanmethemoglobin technique and serum ferritin was assessed by an enzyme-linked immunosorbent assay (Enzymum Test Ferritin, Bohringer Manheim).

RESULTS

Of the expected 2,880 persons in the total sample size, 2,441 persons could be examined, but 79 were omitted because of incomplete data. Therefore a total of 2,331 cases were analysed.

Hookworm infection was found in 560 persons among 2,331 samples, giving a prevalence of 24.02%. Most (61%) of the hookworm infections were associated with *Ascaris lumbricoides* and *Trichuris trichiura* (triple) infections, 17.7% with *Ascaris* infection, 16.3% with *Trichuris* infection, and only 5.5% as a single infection. *Necator americanus* was found to be the most prevalent hookworm species (Table 1).

Most of the hookworm infections were light or very light in intensity, with a mean EPG of 619. The classification of intensity of infection was based on the criteria of Keller *et al* as quoted by Pessigan *et al* (1958) : EPG 1 - 99 = very light, EPG 99 - 699 = light, EPG 700 - 2,599 = moderate, EPG 2600 - 12,599 = severe and EPG more than 12,600 = very severe (Table 2).

Table 1

Hookworm species found among 355 cases of hookworm infection in rural population of Bali.

Hookworm species	Number of cases	Percentage
N. americanus	342	96.1
Combination of *N. americanus* and *A. duodenale*	12	3.6
A. duodenale	1	0.3

Table 2

Intensity of infection of 503 cases of hookworm infection in rural population of Bali.

Intensity of infection	Number of cases	Percentage
Very light	67	13.3
Light	332	66.0
Moderate	82	16.3
Severe	20	4.0
Very severe	2	0.4

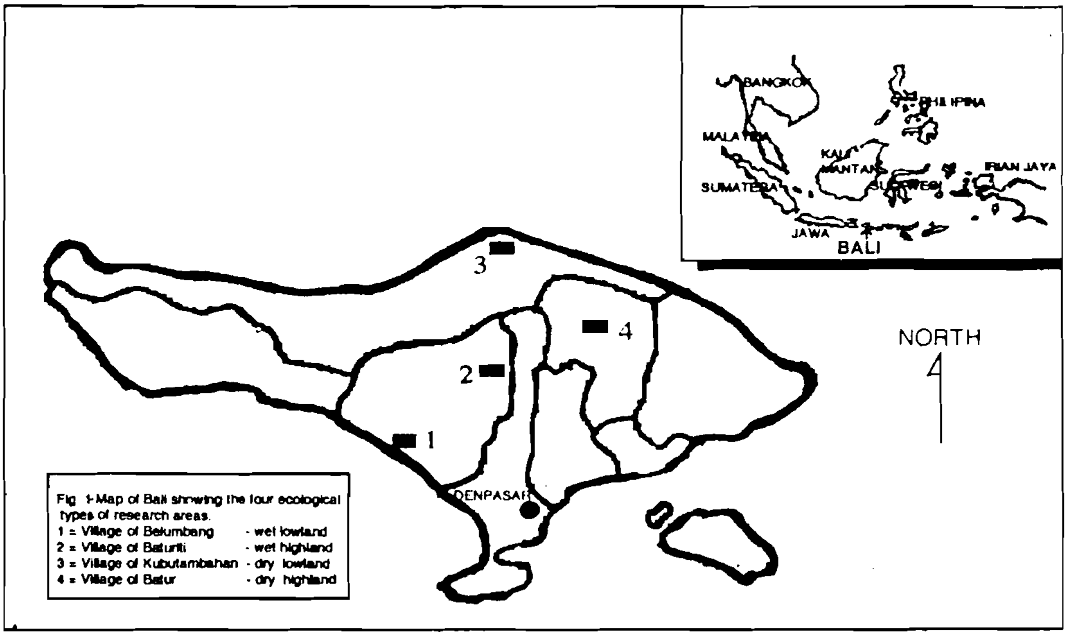

Fig 1—Map of Bali showing the four ecological types of research areas.

There were no significant differences of the prevalence and intensity of infection between male and female (Table 3).

The age - prevalence relationship is shown in Fig 2 and the age - intensity relationship in Fig 3. Both prevalence and intensity of infection were low in childhood, increased steadily with age to reach maximum level in adult-hood, but sligthly decreased in old age. The curves show slight convex configuration.

The prevalence and intensity of infection in the four types of area are shown in Table 5, 6.

There was a significant difference ($p < 0.001$) between the prevalence in wet land (low and highland) and prevalence in dry land (low and highland). The prevalence difference between lowland (dry and wet land) and highland (dry and wet land) was lower ($p = 0.02$). The difference between wet lowland and dry lowland was highly significant with $p < 0.001$.

There were no significant differences in intensity of infection among the four types of area (Table 4).

The frequency distribution of intensity of in-

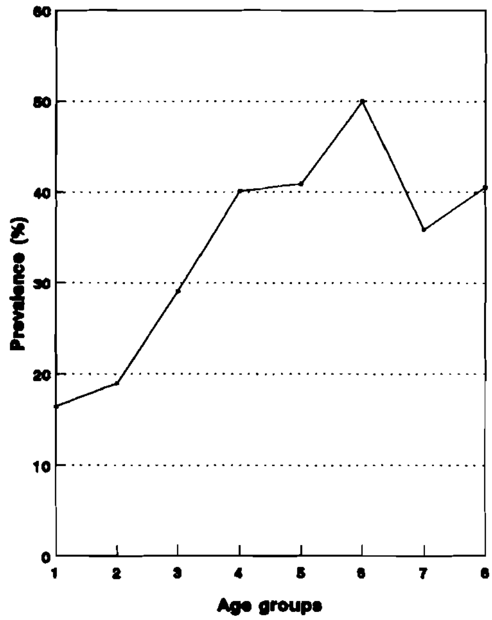

Fig 2—Age-prevalence curve of hookworm infection in rural population of Bali Age groups : 1 ≤ 10; 2 = 10-19; 3 = 20-29; 4 = 30-39; 5 = 40-49; 6 = 50-59; 7 = 60-69; 8 ≥ 70 (years).

Table 3

The prevalence of hookworm infection in rural population of Bali by sex.

Sex	No. examined	Positive	Prevalence %
Male	1,161	315	27.2
Female	1,170	245	20.9

X^2 test → p = 0.071

Table 4

The intensity of hookworm infection in rural population of Bali by sex.

Sex	Mean EPG	Standard deviation
Male	2,052.6	119.9
Female	970.1	66.4

Student's *t*-test → p = 0.2748
EPG = eggs per gram feces

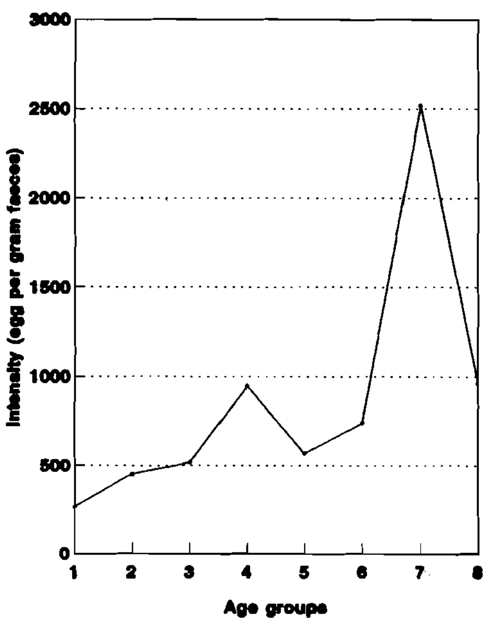

Fig 3—Age-intensity curve for hookworm infection in rural population of Bali Age groups : 1 ≤ 10; 2 = 10-19; 3 = 20-29; 4 = 30-39; 5 = 40-49; 6 = 50-59; 7 = 60-69; 8 ≥ 70 (years)

fection shows an overdispersed distribution pattern. Less than 10% of people harbored 63% of the worm burden (as assessed by EPG), while 90% of people harbored only 34% of worm burden. Fig 4 shows the frequency distribution of hookworm egg counts.

The prevalence of anemia among people with hookworm infection was higher than the prevalence of anemia among people without hookworm infection (31.8% vs 29.3%), but this difference was not significant (p = 0.4565). The correlation of EPG with hemoglobin concentration was not significant (r = -0.15667). There was a significant negative correlation between EPG and serum ferritin (r = -0.15924, p < 0.05).

DISCUSSION

With an overall prevalence of 24.02%, hookworm infection in the rural population of Bali was rather low compared with the overall prevalence in Indonesia (52 - 69%) as shown by results of surveys carried out by NAMRU 2 workers (Carrol and Walker, 1990). However, hookworm infection in Bali must be considered as a health problem because the prevalence is greater than 10%. According to the Indonesian National Soil-transmitted Helminth Control Program, the soil transmitted

Table 5

The relationship between prevalence of hookworm infection and the types of area.

Type of area	No. examined	Positive	Prevalence %
Wet lowland	617	171	27.7
Wet highland	503	233	46.3
Dry highland	727	103	14.2
Dry lowland	484	53	10.9

Table 6

The relationship between intensity of hookworm infection and the types of area.

Type of area	Mean EPG	Standard deviation
Wet lowland	550	918
Wet highland	820	2,020
Dry highland	426	667
Dry lowland	840	3,388

ANOVA test → $p = 0.179$

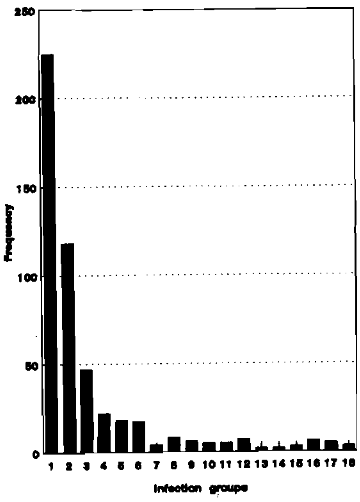

Fig 4—Frequency distribution of hookworm egg counts in rural population of Bali. The number of eggs in each infection category is as follows: 1 ≤ 200; 2 = 200-399; 3 = 400-599; 4 = 600-799; 5 = 800-999; 6 = 1,000-1,199; 7 = 1,200-1,399; 8 = 1,400-1,599; 9 = 1,600-1,799; 10 = 1,800-1,999; 11 = 2,000-2,199; 12 = 2,200-2,399; 13 = 2,400-2,599; 14 = 2,600-2,799; 15 = 2,800-2,999; 16 = 3,000-3,499; 17 = 3,500-9,999 and 18 = over 10.000.

helminth infections should be considered a health problem in a certain area if the prevalence of infection is 10% or above. Chandivana (1990) classified the prevalence rate of hookworm infection as high if the prevalence is > 30%, medium if prevalence is 6 - 30% and low if prevalence is < 6%. As the present study showed, there is marked heterogeneity in the local prevalences. The highest prevalence was found in the wet highland which can be classified as high prevalence. In other areas the prevalence was medium.

Most of the infections were a combination of the three major soil- transmitted helminths, namely *Ascaris lumbricoides, Trichuris trichiura* and hookworm. This phenomenon is also found in other countries in Southeast Asia (Carrol and Walker, 1990). This however differs from the results of surveys done in Papua New Guinea and Zimbabwe, where the prevalence of hookworm infection was found to be high but the prevalences of *Ascaris* and *Trichuris* were very low (Carrol and Walker, 1990; Chandivana, 1990). This difference is not well understood because poor living conditions should facilitate the transmission of all intestinal helminths (Chandivana, 1990).

The most prevalent species found in this study was *N. americanus*. Tantular (1984) and Noerhajati (1978) found the same species in other parts of Indonesia. In Philippines, *N. americanus* was found in 98 - 99% of hookworm infection (Carrol and Walker, 1990). Pritchard *et al* (1989) found 100% *N. americanus* in hookworm infection in Papua New Guinea.

There were no significant differences in prevalence and intensity of hookworm infection between males and females, suggesting that both sexes are equally exposed to the contaminated environment.

There is a consistent pattern of age-prevalence and age-intensity relationship in hookworm infection (Pritchard *et al,* 1989). The prevalence and intensity increase steadily with age and reach maximum level in adult-hood. It can be explained that the chance of contact with polluted soil increases with age. In older age however, both prevalence and intensity slightly decline. It may be due to the lower chance of contact with polluted soil or else due to development of acquired immunity in older age (Anderson, 1986; Chandivana, 1990). The more convex pattern of both curves is considered as epidemiological evidence that acquired immunity to hookworm infection is existent in the host (Anderson, 1986).

From the difference of prevalence rates between wet land and dry land and between lowland and highland, it can be concluded that the altitude is not an important determinant in hookworm infection, but the condition of soil, whether it is dry or wet, is more important. The differences between ecosystem of wet land, which consists of ricefield, and the basic ecosystem of dry land which is field crops, greatly determine the condition of the soil. Chandivana (1990) stated that the climatic conditions, primarily rain-fall, markedly affected the population density of the infective larvae in soil. The level of environmental sanitation and hygiene as measured by the possession of latrines and the availability of health facilities are nearly the same between wet land and dry land (Suryadhi, 1982). It seems that the condition of the soil which determines the favor-ability for the growth of hookworm larvae is the major determinant of the prevalence of hookworm infection in the rural population of Bali.

The frequency distribution of intensity of hookworm infection in this study was found to be overdispersed, the helminth parasites being markedly aggregated. This finding has been commonly found elsewhere: Schad and Anderson (1985) in India, Haswell-Elkins *et al* (1988) in India, Pritchard *et al* (1989) in Papua New Guinea and Chandivana (1990) in Zimbabwe. The possibility is that the small minority of very heavily infected hosts in each population are predisposed to heavy infection (Keymer and Pagel, 1990). Three groups of factors contribute to this event namely: ecological factors - the polluted soil as the source of infection, sociobehavioral factors which govern the chance of contact to the infective larvae, and genetic factors as expressed by immunity to the hookworm infection (Keymar and Pagel, 1990). In endemic areas where the source of infection and chance for contact with infective larvae are nearly homogeneous, the last factor, genetic/ immunity, may be more important than the other factors (Croll and Ghadirian, 1981). The implication of the predisposition theory is very important for the control strategy of hookworm disease.

Chronic blood loss due to hookworm infection in the intestine causes a decrease of iron store and this terminates with iron deficiency anemia (Roche and Layrisse, 1966). But the results of field studies on the relationship between intensity of infection and hemoglobin level are controversial. Many studies, like this one, have failed to show the correlation between intensity of infection and hemoglobin level. According to Roche and Layrisse (1966) the correlation between hemoglobin and intensity of infection can be shown if the size of the sample is large, if there are enough samples with heavy infection and if there are no other dominant etiologies of iron deficiency in the population. The correlation between intensity of infection with serum ferritin is much easier to show because serum ferritin is more sensitive as a measure of iron stores (Cook, 1982). This study showed such a correlation. Pritchard *et al* (1991) in Papua New Guinea found a significant correlation between plasma ferritin and hookworm burden.

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