HOOKWORM INFECTION AND IRON STORES: A SURVEY IN A RURAL COMMUNITY IN BALI, INDONESIA

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Abstract. A study of the rural population of the village of Belumbang, Province of Bali, Indonesia, has been conducted to assess the relationship between intensity of hookworm infection (hookworm egg count) and iron stores, hemoglobin level or hematocrit. There was a significant negative correlation between serum ferritin level and hookworm egg count. However no correlation was found between hookworm egg count and hemoglobin level or hematocrit. In a separate analysis the above correlation could be shown in male hosts but not in female hosts. It is concluded that hookworm infection, even in light infection, can interfere with iron stores, but in female hosts this effect might be masked by other factors.

INTRODUCTION

Chronic blood loss into the human gut is the classical pathologic feature of hookworm infection which have attracted most research attention. But there are still some controversies concerning the amount of blood loss and the mechanisms involved (Gilles, 1985). Roche and Layrisse (1966) have concluded from a literature review that *Ancylostoma duodenale* is responsible for a loss of 0.14 - 0.4 ml per worm per day and *Necator americanus* of 0.013 - 0.10 ml per worm per day. As hookworm appears as a chronic infection and occurs throughout the lifetime of the host, the cumulative blood loss may eventually lead to iron deficiency state (Pritchard *et al,* 1989; 1991). The relationship between hookworm infection and iron deficiency status is dependent on a delicate balance between: (1) iron content and bioavailability of iron in the diet, (2) the state of iron stores, and (3) the intensity and duration of infection (Roche and Layrisse, 1966). The iron deficiency state consists of three consecutive stages, namely (1) iron depletion stage, the earliest stage in which iron storage is decreased without a decrease in iron supply to erythropoiesis, (2) iron deficient erythropoiesis in which the iron stores are low with a diminished erythroid iron supply but without anemia, and (3) frank iron deficiency anemia. Serum ferritin concentration in healthy adults is proportional to the size of body iron stores and serum ferritin is one of the most senitive parameter for measuring iron stores (Bothwell *et al,* 1979; Cook, 1982; Worwood, 1987). Therefore serum ferritin has a better correlation with the intensity of hookworm infection compared with the correlation of hookworm infection and hemoglobin level, especially in a population in which hookworm infection is light. The present study aimed to assess the relationship between hemoglobin, hematocrit, serum ferritin and intensity of hookworm infection in a village community in Bali, Indonesia.

MATERIALS AND METHODS

Field work was carried out in Belumbang Village, Subdistrict of Kerambitan, Bali Province, Indonesia, in August - September 1989. The total population of this village is 2,714 people, 1,036 males and 1,111 females. Most of the people are traditional farmers who work in ricefields.

Fecal samples were examined by Kato-Katz's thick smear method and test tube cultivation technique of Harada Mori for species identification. Hemoglobin concentration from venous blood was assessed by the cyanmethemoglobin technique, hematocrit by the micro method and serum ferritin level was measured by enzyme-linked immunosorbent assay.

Data on hookworm intensity, hemoglobin, hematocrit and serum ferritin were logarhitmically transformed before analysis.

RESULTS

Of the 620 persons, hookworm infection was found in 167 persons, giving a prevalence of

26.9% The mean EPG (egg per gram feces) was 517.9 with a mean EPG in males of 484.2 and in females 564.6. This difference was not statistically significant (p = 0.2851). Most of the hookworm infection (82%) were very light in intensity (EPG < 699), 13.8% was light (EPG = 700 – 2,599) and 4.2% was moderate (EPG = 2,600 - 12,599). No severe infection was found. Hookworm species found was *N. americanus* in 88.8% and *A. duodenale* in 13.2%

The relationship between hookworm intensity as measured with EPG and hemoglobin levels or serum ferritin is shown in Fig 1.

There was a significant negative correlation between serum ferritin level and hookworm intensity. A negative correlation was also found between hemoglobin level and hookworm intensity, but this correlation was not statistically significant. A positive non-significant correlation was found between hematocrit and hookworm intensity. The same results were found when the analysis was restrictedly done on the male host. If the analysis was restricted to female hosts, all the correlations were not significant (Table 1).

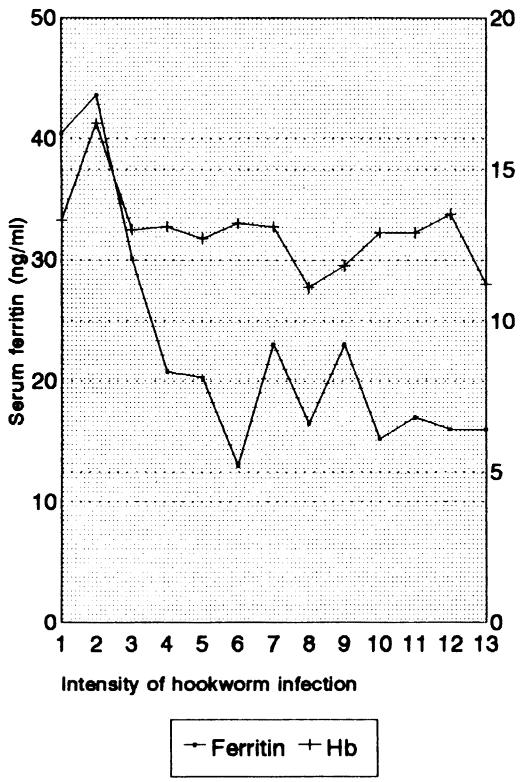

Fig 1—The relationship between hookworm intensity and serum ferritin (—•—) or hemoglobin concentration (+). Intensity of hookworm infection is measured by egg per gram feces: 1 = < 200; 2 = 201 – 400; 3 = 401 – 600; 4 = 601 - 800; 5 = 801 - 1,000; 6 = 1,001 - 1,200; 7 = 1,401 - 1,600; 8 = 1,601 - 1,800; 9 = 1,801 - 2,000; 10 = 2,001 - 3,000; 11 = 3,001 - 4,000; 12 = 4,001 - 5,000; 13 = 5,001 - 10,000.

DISCUSSION

There can be no doubt that hookworm infection causes chronic blood loss which can lead to iron deficiency state (Gilles, 1985). Iron deficiency anemia is the latest stage of iron deficiency state (Bothwell *et al,* 1979). When the intensity of hookworm infection in a case is low, this infection only causes iron deficiency state without anemia. Serum ferritin level is proportional to the size of iron stores and is more sensitive compared with hemoglobin level in measuring body iron stores (Cook, 1982; Worwood, 1987). Therefore, it is easier to show the relationship between hookworm infection and serum ferritin, compared with hemoglobin level or hematocrit.

Pritchard *et al* (1991) in Papua New Guinea found a significant negative correlation between hookworm burden (as measured with worm counting after anthelmentic treatment) and plasma ferritin, but they found no correlation if the hookworm burden is measured by hookworm egg per gram feces. There was no correlation between hookworm burden and hemoglobin level or hematocrit. Shield *et al* (1981), working on male highlanders in Papua New Guinea, demonstrated a highly significant negative correlation between hookworm egg count and both serum ferritin and hemoglobin level. This difference was probably due to difference in intensity of the hookworm infection, being studied.

The results of field studies on the correlation between hookworm infection and hemoglobin level seem conflicting. Roche and Layrisse (1966) reviewed the results of 33 studies carried out up to 1966 and found that only 18 find a correlation. They concluded that several conditions should be fulfilled when investigating the possible correlation between anemia and worm burden, namely : (1) the series studied must be large enough, (2) it should contain a spectrum of cases, extending

Table 1

The relationship between serum ferritin, hemoglobin, hematocrit and intensity of hookworm infection as measured by EPG (egg per gram feces).

	EPG	Levels of significance
All hosts		
Hemoglobin (g/dl)	– 0.0338 (167)*	p = 0.332
Hematocrit (%)	0.0906 (167)*	p = 0.122
Serum ferritin (ng/ml)	– 0.1822 (162)*	p = 0.009**
Male hosts		
Hemoglobin (g/dl)	– 0.1122 (97)*	p = 0.137
Hematocrit (%)	0.1423 (97)*	p = 0.082
Serum ferritin (ng/ml)	– 0.2158 (94)*	p = 0.017**
Female hosts		
Hemoglobin (g/dl)	0.2400 (70)*	p = 0.422
Hematocrit (%)	0.0040 (70)*	p = 0.487
Serum ferritin (ng/dl)	– 0.1373 (68)*	p = 0.128

*Correlation coefficients, with sample sizes in parentheses
**indicating significant difference with $p < 0.05$

from lightly to heavily infected ones, (3) other etrologies of anemias, which might mask the effect of hookworm, should not given be undue importance.

The possible reasons for finding no relationship between hookworm infection and hemoglobin level or hematocrit in our study are: (1) the majority of hookworm infections in our cases were light in intensity with no severe infection; (2) there are other more important etiologies of anemia, such as nutritional factors (low iron content and poor bioavailability of iron in the diet), infections and other causes of chronic blood loss.

In females there are many other causes of iron deficiency beside hookworm infection, such as : excessive menstrual bleeding and increased iron requirement during pregnancy and lactation (Bothwell *et al*, 1979; DeMaeyer, 1989). These factors might mask the correlation between hookworm infection and anemia in female hosts.

From this study it can be concluded that hookworm infection, even in light infection, has a negative effect on iron stores. But in female hosts this effect might be masked by other factors.

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