Tropical Biomedicine 26(1): 57–66 (2009)

Malaria endemicity in an Orang Asli community in Pahang, Malaysia

Gurpreet Kaur
Institute for Public Health, Ministry Of Health Malaysia, Jalan Bangsar, 50590 Kuala Lumpur.
e-mail: drpreet@yahoo.com
Received 3 January 2009; received in revised form 13 February 2009; accepted 18 February 2009

Abstract. An epidemiological cross-sectional study was undertaken to determine the endemicity of malaria among the Orang Asli population of Raub, Pahang. Malaria endemicity was measured in terms of the prevalence of parasitaemia and splenomegaly. A total of 520 Orang Asli were examined. The point prevalence of malaria was 24.2% (95% CI 20.7-25.1), with *Plasmodium falciparum* (67.5%) being the predominant species. Children $\leq$ 12 years were at least 3.7 times more likely to be parasitaemic compared to those older. The prevalence of malaria among children 2-<10 years was 38.1% (95% CI 31.6-50.0). Spleen rate among children 2-<10 years old was 22.3% (95% CI 17.1-28.3). The average enlarged spleen size was 1.2. These findings classify the study area as being mesoendemic. Malaria control activities among the Orang Asli should focus on protecting vulnerable subgroups like young children. Measuring the level of malaria endemicity at regular intervals is fundamental in evaluating the effectiveness of malaria control programs.

INTRODUCTION

Malaria is a disease presenting challenge to mankind, even after 3,000 years of its earliest documentary evidence (Sandosham & Thomas, 1983). The World Health Organisation reported malaria as being endemic in over 109 countries in 2008, with an estimated 247 million cases and nearly a million deaths among the 3.3 billion people at risk in 2006 (WHO Malaria Report, 2008). This is despite malaria control activities having been carried out extensively, since the global malaria eradication program was first embarked in 1955.

In Malaysia, there has been an overall decline in the incidence of malaria over the years (Vector Borne Diseases Section, Ministry of Health, 2007). The majority of reported cases in peninsular Malaysia are focal in nature and largely concentrated among the hinterland Orang Asli population. These are the aboriginal people of peninsular Malaysia. They constitute only 0.6% of the total population in Malaysia (Department of Statistics, 2006) and comprise of 3 main ethno-linguistic groups; the Senoi (55%), Proto-Malays (42%) and the Negritos (3%) and 18 dialectic sub-groups. They are mainly concentrated in the states of Perak, Pahang, Kelantan, Selangor, Negeri Sembilan and Johor. With 50.9% and 15.4% of them classified as poor and hardcore poor respectively, the Orang Asli are a largely socio-economically disadvantaged population (Economic Planning Unit, 2001). In spite of a systematic public health care system in place for them, malaria remains a concern. In order to address this problem and to evaluate the effectiveness of current malaria control measures, the local epidemiology of malaria in the Orang Asli population needs to be assessed and quantified.

The study aimed to determine the endemicity of malaria among the Orang Asli of Raub, Pahang defined by two independent malariometric measures. The area was selected based on the district's relative high number of cases within the state and accessibility via land, given the limitations and resources for the study.

MATERIALS AND METHODS

A cross sectional study was conducted among the Orang Asli population of the Raub district in the state of Pahang as part of a study that also looked at the risk factors of malaria in that community. This paper only describes findings from the study in relation to endemicity.

Study Area

Raub is positioned at coordinates 3º 48' 0" North and 101º 52' 0" East (Google Satellite Maps, 2009), measuring 2269 km^2 with an estimated population of 79,488 people (Department of Statistics, 2005). The district has in the West, the states of Perak and Selangor forming the northern and southern boundries (Figure 1). It shares a boundry with the district of Lipis in the north, Jerantut in the east, Temerloh in the southeast and Bentong in the south. The western and northern regions of the district are mainly hilly.

The Orang Asli in Raub comprise of the Senoi and the Pro-Malays (Department of Orang Asli Affairs, 2001). The dialectic sub-groups that predominate are the Semai, Che Wong and Temuan groups, of which the Semai are the majority.

There are 19 Orang Asli villages in Raub, of which majority or 90% are located at the forest fringes (Department of Orang Asli Affairs, 2001). The population of these villages range from between 31 to 451 people. Most of these villages are accessible only by four-wheel drives, while others only by foot. The villages are situated between 10 to 65 kilometers away from the town centre.

Sample size and sampling technique

Sample size was determined based on a population survey method using the Epi Info version 6 software. An estimated sample size of 138 was obtained based on an estimated prevalence of 10% parasite rate among those > 12 years old, to be estimated within a precision of 5% at 95% confidence interval (CI). Similarly, for children $\leq$ 12 years old, the sample size required for an estimated spleen rate of 25% within a precision of 10% at 95% CI was 72. Thus the minimum total sample size required for the population survey was 210. It was inflated by at least 50% to 315 to take into account of possible non-response due to absence of the study subjects when the survey was being conducted during the day. The study was conducted from August 2000 to April 2001.

A simple random sampling of the Orang Asli villages followed by a total population survey of the selected villages was carried out. Ten villages were randomly selected (Figure 1). In order to ensure a margin of safety for obtaining an adequate sample size, all Orang Asli who were currently residing and present in that village during the time of the survey were included in the study.

Study Design

Information on socio-demography such as age, sex, marital status, main occupation and household income was obtained. A single finger prick thick and thin blood smears were obtained from each subject by two trained Public Health Assistants from the local malaria control team. All slides were sent within a week to a tertiary teaching hospital where it was stained with Giemsa and examined by a consultant parasitologist. The slides were examined for the malaria species, stage of the plasmodium and parasite count.

Physical examination of the abdomen was carried out to examine the presence of palpable spleen and its size on all Orang Asli's 12 years and below only. Spleen palpation was done with the children both lying down supine and standing (Swash, 1990), and classification of spleen size was according to Hackett (WHO, 1963).

Data Analysis

Parasite count, which was based on the number of parasites found in relation to fields of a thick film, was classified into four classes. The classes were assigned as +, ++,

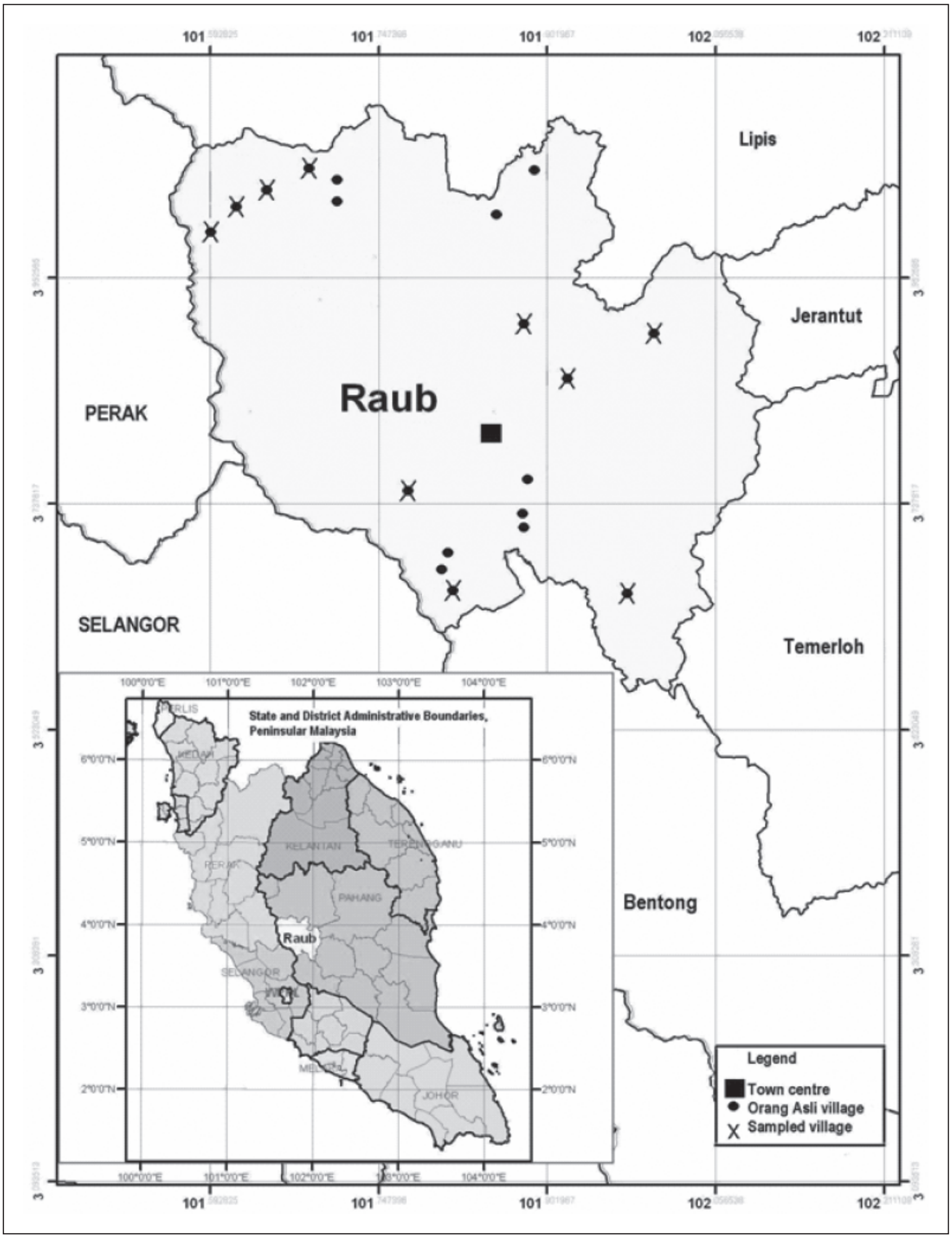

Figure 1: Geographical location of Raub and the approximate locations of the Orang Asli villages.

+++ and ++++ corresponding to 1-10 and 11-100 parasites per 100 thick film fields, and 1-10 and >10 parasites per single thick field respectively (Bruce-Chwatt, 1980).

Both SPSS version 13.0 and Epi Info version 6.0 statistical programs were used to analyse the data. A significance level of 0.05 (2 - tailed) at 95% confidence interval (CI) level was chosen.

RESULTS

Comparison Between The Study Sample And Study Population

A total of 520 Orang Asli from 10 randomly selected villages were successfully included in the study. This figure represents 20.9% of the total Orang Asli population in Raub. A majority of both the study sample (58.3%) and study population (54.2%) comprised of those below 15 years of age. About half (50.7%) of the study population were males, while the reverse was true of the study sample where females predominated. However, the study sample did not differ significantly from the study population with respect to both age group and sex (Table 1).

Description of the study sample

The study sample comprised of between 10 and 103 Orang Asli from each of the ten villages. A majority of the study sample were children below 15 years of age (58.3%), females (50.4%), had at least primary school education (51.2%), earned a monthly household income of between RM# 100.00 - < 250.00 (61.7%), used the gravity feed system for water supply (55.8%) and were self employed, gathering jungle produce for a living (54.5%) (Table 2).

Malariometry

Of the total 520 slides examined, 126 were found positive for the malaria parasite, thus giving an overall slide positivity rate (SPR) of 24.2% (95% CI, 20.7-28.1). The slide positivity rate of the 10 villages ranged between 12.5% and 42.1% each. The majority (67.5%) of infections comprised of *Plasmodium falciparum* while the rest were *Plasmodium vivax*. There were no mixed infections. The *species infection rate was 16.3% for *P. falciparum* and 7.9% for *P. vivax*. The parasite formula was **F 67.5, V 32.5. While the parasite count ranged from between + and +++, 80.9% were classified as +. Only 13 cases (10.3%) were identified as having a +++ class of parasite count. These 13 cases were also positive for gametocytes. In the rest of the cases, only asexual forms (trophozoites) of the parasite were detected in various stages of development.

* Species infection rate = number of species specific positive cases / total number of cases examined X 100.

** Parasite formula = F (number of *falciparum* positive cases / total number of positive slides x 100), V (number of *vivax* positive cases / total number of positive slides x 100) (WHO, 1963).

\# Note: 1 USD approximately equals to RM 3.64 (Starbiz, Exchange rate, Feb 13 2009, The Star. pg B16).

A total of 61 respondents ≤ 12 years old had palpable spleens, thus giving a spleen rate of 20.2% (95% CI, 15.96-25.01) among children ≤ 12 years old. The class of spleen size categorises the size of the spleen palpated. It ranged from 0 to 3, where 0 indicates a non-palpable spleen. The majority of enlarged spleen (85.5%) was classified as size 1. The average enlarged spleen (AES) size was 1.2. This is calculated as the mean spleen size among those with a palpable spleen. Table 3 shows the malariometric findings.

Table 1. Socio-demographic comparison between the study sample and the study population

Variable	Study sample (%)	Study population (%)	p-value (*Y*)	cOR (95% CI)
Age (years)			0.0968	
≥ 15 *	217 (41.7)	1138 (45.8)		
< 15	303 (58.3)	1345 (54.2)		1.2 (1.0-1.4)
Gender			0.6988	
Male *	258 (49.6)	1258 (50.7)		
Female	262 (50.4)	1225 (49.3)		1.0 (0.8-1.2)

Y – Yates corrected. cOR –crude odds ratio. 95% CI -95% confidence interval. * reference group.

Table 2. Frequency distribution of study sample by socio-demographic characteristics

Socio-demographic variables	Frequency (n = 520)	Percentage (%)
Village		
Pos Buntu	91	17.5
Pos Kelang	69	13.3
Ulu Yol	103	19.8
Ruai Hilir	57	11.0
Ruai Hulu	55	10.6
Temir	76	14.6
Sg. Ruyung	19	3.7
Sempam	24	4.6
Sg. Kepong	16	3.1
Tok Machang	10	1.9
Age group (years)		
< 02	25	4.8
02 - < 05	57	11.0
05 - < 10	158	30.4
10 - < 15	63	12.1
≥ 15	217	41.7
Gender		
Male	258	49.6
Female	262	50.4
Marital status (n=226)		
Single	61	27.0
Married	162	71.7
Divorced	3	1.3
Educational status (n=342)		
None	120	35.1
Kindergarten	35	10.2
Primary	175	51.2
Secondary	12	3.5
Monthly household income (RM) *		
≥ 500.00	31	6.0
250.00 - < 500.00	127	24.4
100.00 - < 250.00	321	61.7
< 100.00	41	7.9
Source of water supply		
Tap	145	27.9
Gravity Feed & Tap	12	2.3
Gravity Feed	290	55.8
Well	11	2.1
River	62	11.9
Main occupation (n=213)		
Jungle Produce Gatherers	116	54.5
Agricultural Sector	77	36.1
Hunting	7	3.3
Trading	3	1.4
Others	4	1.9
Housewife	6	2.8

* Poverty line in peninsular Malaysia is RM 540.00 per month for a family of five (Economic Planning Unit, 2001).

Table 3. Frequency distribution of study sample by malariometric variables

Malariometric variables	Frequency	Percentage (%)
Parasite (n=520)		
Yes	126	24.2
No	394	75.8
Parasite species (n=126)		
P. falciparum	85	67.5
P. vivax	41	32.5
Parasite density (n=126)		
P. falciparum (84)		
1+	71	56.4
2+	11	8.7
3+	2	1.6
P. vivax (42)		
1+	42	33.3
2+	0	0.0
3+	0	0.0
Spleen palpable (n=302)		
Yes	61	20.2
No	241	79.8
Class of spleen (n=302)		
0	241	00.0
1	52	85.2
2	8	12.9
3	1	1.6

The SPR was highest i.e., 47.4% among children 2-<5 years old, followed by 34.8% among children between 5-10 years old (Table 4). Overall, the SPR among children <15 years was 33.0% (95% CI 27.9-38.5%). Only 12.0% of respondents aged 15 years and above were found positive for malarial parasites. The SPR among children 2-<10 years of age was 38.1% (95% CI 31.6-50.0%).

The difference in parasite rates between the various age groups was significant. Compared to children <2 years, children between 2-5 years were at least 4.7 times more likely to be parasitaemic. Although there was an apparent decline in the likelihood of parasitaemia as age increased from 5 years onwards, the association was not significant. Overall, children ≤ 12 years were at least 3.7 times more likely to develop parasitaemia compared to those > 12 years.

The age specific spleen rates showed a similar trend as age specific parasite rates. Children aged 2-<5 years had the highest

Table 4. Frequency distribution and association of malariometric parameters and age

Variable	Number examined	Number positive (%)	p-value	cOR (95% CI)
Parasitemia			0.0000	
Age group				
<02 *	25	4 (16.0)		
02-<05	57	27 (47.4)		4.7 (1.4-15.5)
05-<10	158	55 (34.8)		2.8 (0.9-08.6)
10-<15	63	14 (22.2)		1.5 (0.4-05.1)
15	217	26 (12.0)		0.7 (0.2-02.3)
Spleenomegaly (n=302)			0.3716	
Age group				
<02 *	25	2 (08.0)		
02-<05	57	14 (24.6)		3.7 (0.8-17.9)
05-<10	158	34 (21.5)		3.2 (0.7-14.0)
10-≤12	62	11 (17.7)		2.5 (0.5-12.1)

* reference group. cOR- crude odds ratio. 95% CI – 95% confidence interval.

spleen rate of 24.6%, followed by a spleen rate of 21.5% among children 5-10 years of age. Spleen rate was lowest in children less than 2 years. The overall spleen rate among children 2-<10 years was 22.3% (95% CI, 17.1-28.3). The difference in the spleen rates by subgroups of age was not significant. It appears that children between 2-12 years of age have a higher likelihood of enlarged spleens when compared to children <2 years. The likelihood of splenomegaly also appeared to decline with increase in age from 2 to 12 years. However, the association was not significant, and the confidence interval of the estimate was large.

DISCUSSION

The level of endemicity of malaria in a defined population is indicated by its frequency of occurrence in relation to time and place. As the infection may give rise to a wide spectrum of manifestations, ranging from asymptomatic to death, various measurements may be employed to quantify the occurrence of malaria. The relative usefulness of a particular parameter of measure of malaria occurrence in one population compared to another is largely dependent on the magnitude and severity of the disease in that population, the feasibility of eliciting the measurement, and its applicability in the evaluation and monitoring of malaria control activities. Conventionally, malaria is identified by a positive blood smear for plasmodia. However, parasitaemia does not equate to clinical morbidity, nor is it an indication of the cumulative experience of the individual or population to the infection. Hence, different parameters of measure only provide part of the whole picture of malaria endemicity in the population. A combination of two or more measures would serve to be more comprehensive in determining the magnitude of malaria endemicity.

A number of malaria studies in Malaysia have used different measures at a single point of time, such as parasitological, clinical and serological (Bolton *et al.*, 1972; Thomas & Dissanaike, 1977; Thomas *et al.*, 1980; Mathews & Dondero, 1982; Mak *et al.*, 1987; Premaraj *et al.*, 1993a, Mahdy *et al.*, 2004). This paper describes the point prevalence of malaria using two independent measures of the level of malaria endemicity, i.e., the parasitological and spleen rates. Although respondents were comparable with non-respondents, limitations in the study design and sampling method could possibly introduce selection biases which must be taken into account when interpreting the findings.

The population point parasite prevalence rate was 24.2% (95% CI 20.7-28.1). The prevalence in Pos Buntu and Pos Kelang specifically was about 1.8 times higher than that previously reported in the same area by Premaraj *et al.* (1993b). In other forest fringe or deep jungle populations, parasite rates have ranged from 4.4% to 12.7% (Mak *et al.*, 1987; Norhayati *et al.*, 2001; Mahdy, 2004). Among other factors, the observed differences in the magnitude of the prevalence rates in these studies can be largely attributed to differences in the intensity of malaria transmission and the effectiveness of local malaria control measures over time in the areas concerned. Prior to there being any malaria control activities, one of the earliest malaria surveys among the Orang Asli in the 1930's found high parasite and spleen rates of about 35% each (Bolton, 1972). The rates fell gradually to about 5% in the next two years with aggressive chemoprophylaxis.

In Raub, the main malaria control strategy among the Orang Asli has been through active case detection (ACD), passive case detection (PCD), massive blood surveys, residual spraying and the distribution of treated bed nets. During the study, the author also sought to elicit information on some of these activities from the respondents. Although majority of respondents (92.3%) claimed to have had their houses sprayed with insecticides in the past, about 60% of them reported that it was done more than 6 months ago. Hence, in interpreting the high malaria prevalence in this area, one must take into account of possible factors that may have contributed to the ineffectiveness of the malaria control program in this area over time. This would include compliance for malaria chemoprophylaxis and the use of bed nets. This study however, did not look into the problems and effectiveness of the district's malaria control program in detail.

The predominance of *P. falciparum* species, followed by *P.vivax* in blood smears is similar to other studies (Bolton, 1972; Mathews & Dondero, 1982; Mahdy *et al.*, 2004). Conversely, Norhayati *et al.* (2001) found *P. vivax* as the predominant species in an Orang Asli village in Perak. Mixed infections were not found in this study. This is not unusual, since mixed infections are not common in the district. In the few years preceding the study only < 1.4% of the total yearly malaria cases in Raub were due to mixed infections (Raub District Health Office, 2008). The absence of *Plasmodium malariae* in the area suggests that this species may have been successfully controlled with the current malaria control activities. In the early days, *P. malariae* parasites were almost eliminated compared to other species when malaria control measures were implemented aggressively among the Orang Asli (Bolton, 1972). In other isolated Malaysian populations where *P. malariae* was initially the predominant parasite, the infection rate dropped considerably without any control measures (Sandosham & Thomas, 1983). Majority of the parasitaemia in this study was of low density levels (+). It is not possible to determine if these low parasitaemia levels correspond to the early phase of patency, recrudescence, relapse, parasite drug resistance or simply to the strong host defense mechanisms without additional information. Ten percent of cases had gametocytes indicating that they had been infected for a considerable time. These cases with gametocytes are the reservoirs of the disease that ensures there is continuous transmission of malaria.

Parasite rates were highest among younger children compared to adults, and gradually declined with age. The most vulnerable group to develop parasitaemia in this population were children between 2 to <5 years old. The findings concur with a study by Premaraj *et al.* (1993b) done in the same district earlier which found children four years of age or younger to be most vulnerable to the infection. Mak *et al.* (1987), Norhayati *et al.* (2001) and Mahdy *et al.* (2004) also found Orang Asli children less than 10-12 years having significantly higher rates of malaria compared to older children and adults. The vulnerability of children may be related to specific differences in host immune response factors. The findings are typical of a population who experienced moderate to high levels of malaria transmission beginning early in life (Trape *et al.*, 1993). The trend of declining parasite rates with increasing age is observed, as children are the most vulnerable group, acquiring partial immunity to the infection as they experience an increased number of malaria infections over the years. Even children < 2 years have been shown to acquire the infection at a greater proportion than adults in this study. This would be unexpected if one considers the relative immunity of children < 1 and the least risk of exposure to infective mosquitoes that these children have had since they almost exclusively spent their days within the villages. However, it has been suggested that babies have a greater tolerance to mosquito bites and this may contribute to the feeding success on them (Port *et al.*, 1980). The presence of parasitaemia within this age group suggests that active transmission has occurred within the villages itself.

The spleen rate has been suggested as the most important single item to determine the intensity of malaria transmission (Sandosham, 1984). The spleen rate among children 2-9 years was just over 22.0%. Other studies have shown spleen rates among children ranging from 20.0% to 81.8% (Thomas *et al.*, 1981; Mak *et al.*, 1987). Norhayati *et al.* (1998) found an overall spleen rate of 19.8% among children and adults in an Orang Asli village in Perak. In Pahang, spleen rates among children ranged from 14.8% to 44.2% in a study evaluating various intervention methods using bed nets (Mak, 1995). Spleen rates of less than 5% have only been recorded in the mid 1930's when malaria chemoprophylaxis was first aggressively instituted in a lowland Orang Asli community in Perak (Bolton, 1972). This study also found no significant differences in spleen rates among children ≤ 12 years, indicating that all age groups of the children were equally likely to develop splenomegaly with parasitaemia. However, between the ages 2 to 12 years, there was an apparent decline in the rates of splenomegaly. The findings support the fact that with increasing age and acquisition of immunity, the spleen has a less important role to play in host defense against malaria. However, in areas where there has been intermittent and often incomplete treatment of malaria, immune response may be altered, resulting in altered patterns of splenic enlargement. In areas of intense transmission where chemotherapy is minimal, spleen rate and size may be used accurately to study endemicity patterns (Trape *et al.*, 1994). The average spleen size in this population was lower than reported in another forest fringe Orang Asli population in Selangor, where the malaria prevalence among children < 10 years old was also higher compared to this population (Mak *et al.*, 1987).

Based on both the parasite and spleen rates, the study population was typical of a mesoendemic population (Bruce-Chwatt, 1985). The findings concur with other local studies (Bolton, 1972; Mak *et al.*, 1987; Mak, 1995) where malaria control measures had not been aggressively instituted yet. In contrast, there have also been reports of populations with hyperendemic spleen rates within Malaysia (Sandosham & Thomas, 1983; Thomas *et al.*, 1981).

This study describes the local epidemiology of malaria among the Orang Asli population of Raub. The findings also suggest that malaria control activities must be intensified especially among children, as they are more vulnerable to suffer from effects of the infection and its complications. It is recommended that the local magnitude of malaria endemicity be measured from time to time as an indicator of the effectiveness of the malaria control program in that area.

Acknowledgements. This research was supported by a grant from the University of Malaya (Vot F:F0060/2000B) for the purpose of completing a post-graduate degree. The author would also like to thank the Director General of Health, Ministry of Health Malaysia for his permission to publish this paper.

REFERENCES

Bolton, J.M. (1972). The control of malaria among the Orang Asli in West Malaysia. *Medical Journal of Malaysia* **27**(1): 10-19.

Bruce-Chwatt, L.J. *Essential Malariology*. (1985). 2nd Edition. London: William Heinemann Medical Books Limited, pg 114, 185.

Department of Orang Asli Affairs (2001). *Information on Orang Asli socio-demographics in Raub*. Unpublished data.

Department of Statistics Malaysia. (2005). Yearbook of Statistics, Malaysia 2005. Department of Statistics Malaysia.

Department of Statistics Malaysia. (2006). *Profile of the Orang Asli in Peninsular Malaysia*. Department of Statistics Malaysia.

Economic Planning Unit, Prime Minister's Department, Government of Malaysia. *Eighth Malaysia Plan 2001-2005*. (2001). Kuala Lumpur: Government Printers.

Google Satellite Maps (2009). *Raub Map – Satellite images of Raub* [Cited 28 January 2009]. www.//http:maplandia.com/malaysia/pahang/raub/

Mahdy, M.A.K., Chan, B.T.E., Noor Hayati, M.I., Sa'iah, H.A., Ismail, M.G. & Jeffery, J. (2004). The distribution of malaria parasites among Orang Asli populations living in the interior areas of Pahang and Kelantan, Malaysia. *Tropical Biomedicine* **21**(1): 101-1-5.

Mak, J.W. (1995). Medicine in Malaysia: Parasitic diseases. *Medical Journal of Malaysia* **5**: S60-S64.

Mak, J.W., Lim, P.K., Tan, M.A., Lam, P.L., Noor Rain, A., Selvadurai, G.D. & Hanjeet, K. (1987). Parasitological and serological surveys for malaria among inhabitants of an aborigine village and an adjacent Malay village. *Acta Tropica* **44**: 83-89.

Mathews, H.M. & Dondero, T.J.Jr. (1982). A longitudinal study of malaria antibodies in a Malaysian population. *American Journal of Tropical Medicine and Hygiene* **31**(1):14-23.

National Institutes of Health (February 2007). *Understanding malaria. Fighting an ancient scourge*. National Institutes Of Health. [Cited 2008 Jan 4] www.niad.nih.gov

Norhayati, M., Noor Hayati, M.I., Nor Fariza, N., Rohani, A.K., Halimah, A.S., Sharom, M.Y. & Zainal Abidin, A.H. (1998). Health status of Orang Asli (aborigine) community in Pos Piah, Sungai Siput, Perak, Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health* **29**(1): 58-61.

Norhayati, M., Rohani, A.K., Noor Hayati, M.I., Halimah, A.S., Sharom, M.Y., Zainal Abidin, A.H. & Fatmah, M.S. (2001). Clinical features of malaria in Orang Asli population in Pos Piah, Malaysia. *Medical Journal of Malaysia*, **56**(3): 271-271.

Port, G.R., Boreham, P.F.L. & Bryan, J.H. (1980). The relationship of host size to feeding by mosquitoes of the *Anopheles gambiae* Giles complex (Diptera, Cullicidae). *Bulletin of Entomological Research* **70:** 133-144.

Premaraj, P., Mustafakamal, I. & Muhamed, K. (1993a). Malaria Microscopy: A comparative study of giemsa-stained thick smear and acridine fluorescent microscopy. *Tropical Biomedicine* **10**(2): 139-144.

Premaraj, P., Mustafakamal, I. & Muhamed, K. (1993b). Criterion of fever in malaria surveillance. *Tropical Biomedicine* **10**(2): 145-148.

Raub District Health Office, Pahang, Ministry of Health, Malaysia (2008). *Data on incidence of malaria in Raub, 1997-2007*. Unpublished Data.

Sandosham, A.A. (1984). Perspectives in Medicine: Malaria. *Medical Journal of Malaysia* **39**(1): 5-20.

Sandosham, A.A. & Thomas, V. (1983). *Malariology With Special Reference To Malaya*. Singapore: University Press, Singapore. pg 9, 98, 104.

Swash, M. (1990) *Hutchinson's Clinical Methods*. 19^{th} Edition. ELBS Series, Kent: Mackays of Chatham PLC. pg 102-103.

The Global Fund. *HIV/AIDS, Tuberculosis and Malaria: The status and impact of the three diseases*. Report From The First Replenishment Meeting of The Global Fund. Switzerland. 2005 [Cited 2008 Jan 4]. www.theglobalfund.org

Thomas, V. & Dissanaike, A.S. (1977). Malaria endemicity among Orang Asli (Malaysian Aborigines) as determined by indirect fluorescent antibody tests. *American Journal of Tropical Medicine and Hygiene* **26**(4): 602-606.

Thomas, V., Ho, K.B. & Yap, P.L. (1980). Seroepidemiology of malaria in Peninsular Malaysia: *Plasmodium falciparum* antibody profile of adults in four states. *Transactions of the Royal Society of Tropical Medicine & Hygiene* **74**: 375-380.

Thomas, V., Hock, S.K. & Yap, P.L. (1981). Seroepidemiology of malaria: age-specific pattern of *Plasmodium falciparum* antibody, parasite and spleen rates among children in an endemic area in peninsular Malaysia. *Tropical Doctor* Oct; **11**(4):149-54.

Trape, J.F., Lefebvre-Zante, E., Legros, F., Druilhe, P., Rogier, C., Bouganali, H. & Salem, G. (1993). Malaria morbidity among children exposed to low seasonal transmission in Dakar, Senegal and its implications for malaria control in tropical Africa. *American Journal of Tropical Medicine and Hygiene* **48:** 748-756.

Trape, J.F., Rogier, C., Konate, L., Diagne, N., Bouganali, H., Canque, B., Legros, F., Badji, A., Ndiaye, G., Ndiaye, P., Brahimi, K., Faye, O., Druilhe, P. & Da Silva, L.P. (1994). The Dielmo project: a longitudinal study of natural malaria infection and the mechanisms of protective immunity in a community living in a holoendemic area of Senegal. *American Journal of Tropical Medicine and Hygiene* **51:** 123-137.

Vector Borne Diseases Section, Disease Control Division, Department of Public Health, Ministry of Health, Malaysia (2007). *Malaria situation until May 2007.* [Cited 2009 20 Jan] http://www.dph.gov.my/vektor/buletin/pdf/MALARIA%20SITUATION.pdf

World Health Organisation (WHO). (1963) *Terminology of Malaria And Malaria Eradication.* Geneve: WHO, Pg 40, 46.

World Health Organisation (WHO). *World Malaria Report 2008*. [Cited 2009 Jan 20] http://www.who.int/malaria/wmr2008/malaria2008.pdf