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Original article

Malaria epidemiology and control methods in specific geographical foci in Lombok and Sumbawa islands of Indonesia; (I) epidemiology

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Abstract: Malaria epidemiological surveys were carried out in two subdistricts; Meninting of Lombok island and Utan of Sumbawa island, Indonesia in 2002 through 2003. In Meninting, distribution of hypo- to meso- endemicity was observed mainly in hilly forested areas and partially in coastal areas with no distribution in the more densely populated flat areas surrounded by rice fields. In contrast, in Utan the distribution was limited to the coastal areas. In Utan, treatment follow-up studies revealed the prevalence of chloroquine resistant *Plasmodium falciparum* (*P. f.*). Although the degree of malaria endemicity in the two areas was regarded as hypo- to meso-endemic, the majority of affected individuals were under the age of ten, and the number of positive cases declined with increasing age. Interestingly, age dependence to species-specific infection was observed, younger children being more prone to *P. vivax* infections than to *P. f.*
Key words: malaria, epidemiology, Lombok island, Sumbawa island, Indonesia

INTRODUCTION

The Republic of Indonesia, a large archipelago comprised of over 13,000 islands stretching along the equator, has been listed among the malaria endemic countries in Southeast Asia. Epidemiological situations vary widely among islands and can be strikingly different between districts of the same island [1, 2]. In economically developed regions of Java and Bali, malaria has been eliminated except for the occasional report of an outbreak in places where malaria was present in the past. Meanwhile, pockets of transmission remain throughout the islands outside of Java - Bali and show varying degrees of endemicity. During the period of 1991 to 2000, malaria epidemiological surveys were conducted in three subvillages of West Lombok and three subvillages in Sumbawa of Nusa Tengara Barat (NTB) Province [2]. Based on previous data and experience, the Malaria Control Project in Lombok and Sumbawa Islands was commenced in October 2002 with the cooperation of NTB Provincial and District Health Offices, and the Tropical Disease Center (TDC) of Airlangga University. Together with the Japanese organization, these facilities functioned as implementation groups under financial support from the Japan International Cooperation Agency (JICA). This report describes the epidemiological aspects, prior to control measures in the two model subdistricts, Meninting in West Lombok and Utan Rhee in Sumbawa.

MATERIALS AND METHODS

1. Survey Areas.

The malaria surveys were carried out in two communities affiliated with two health centers, one in each of the two main islands of NTB Province. In Lombok, the community affiliated with the Meninting health center, hereafter referred to as Meninting area, was selected as one of the control sites (Fig. 1). Due to a heavy reliance on tourism, malaria outbreaks can have a devastating impact on health and the economy. This was one of the key factors when choosing a location for the control trials in Meninting area covering 12 km of coastal terrain facing the Strait of Lombok. Along the narrow coastal plains, lush hilly forests roll from the northern part and stretch inland. A fifth of the area covering the south is a plain with rice fields. According to cen-

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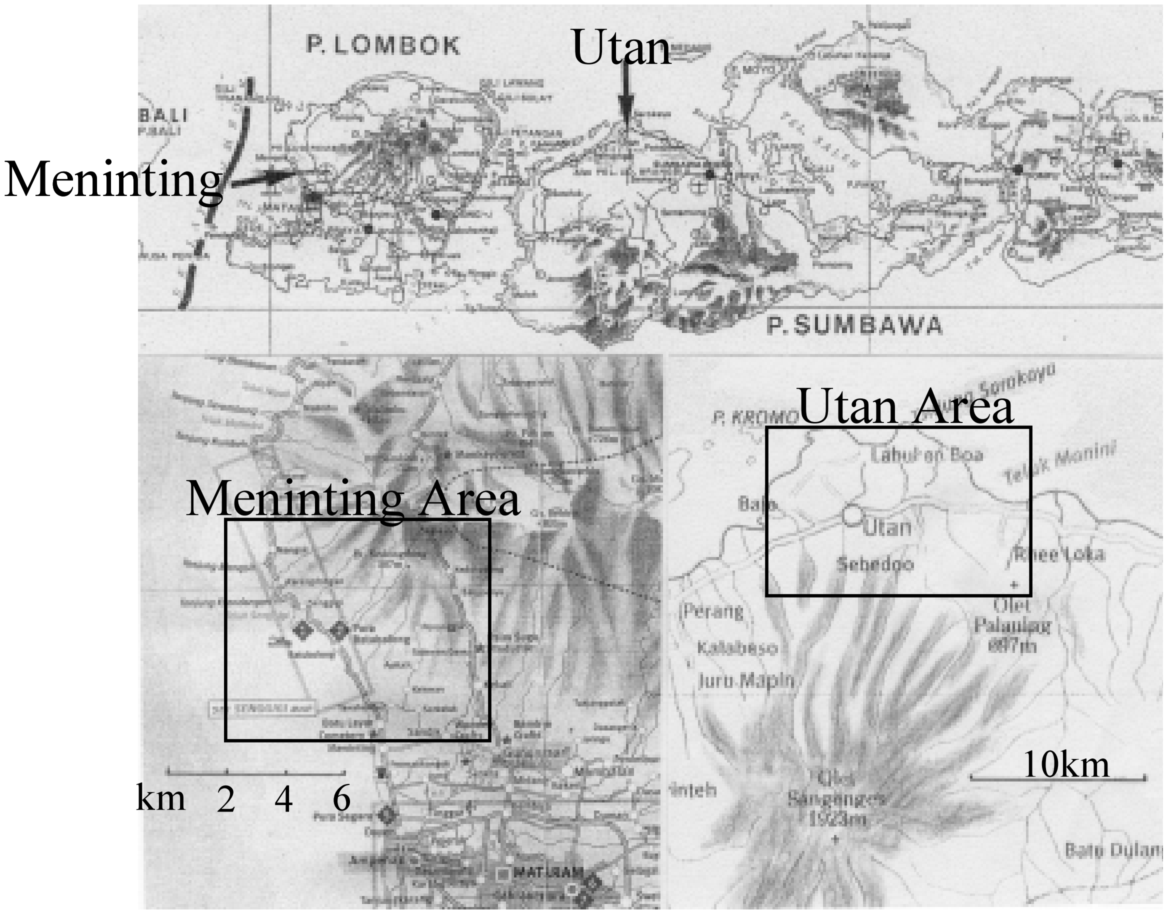

Fig. 1. Location of the two project areas in Lombok and Sumbawa islands, Indonesia.

sus data from 2003, Meninting had a population of 37,000 with 9,900 households in six villages (desa) divided into 48 subvillages (dusun). Most of the population live in coastal areas and plains, and only about 5,000 population live in forested hills. In Sumbawa, the community affiliated with the Utan Rhee health center on the northern coast of Sumbawa district, hereafter referred to as Utan area, was selected (Fig. 1) for its moderate endemicity confirmed in previous surveys [2]. In Utan, most of the coast is lined with mangroves, with vast plains spreading from the coast to the hilly inland region. In places where mangrove trees have been removed, fish ponds have been developed for sustainable farming. The plains are cultivated to harvest rice during the rainy season and soy beans during the dry season. In 2002, the population of Utan was 32,000. Most of the people lived along the coast or flat lands, with a population of less than 1,000 living in the hilly area. Utan has 13 villages (desa) including 37 subvillages (dusun).

2. Spleen Examination of School Children.

To understand the distribution of endemic malaria in the two areas, spleen examinations were carried out on school children in the first and second grades throughout Meninting in November 2001 and throughout Utan in October 2002 [3, 4]. The location of schools and number of examined children are shown in Fig. 2 and 3 and Table 1 and 2.

3. Regular (Quarterly) Surveys at Selected Subvillages.

Based on the results of the spleen examinations and records previously submitted by the Meninting health center, four subvillages including three subvillages along the coast (Kerandangan, Batulayar, Montong Buwuh) and one from a forested area (Kedondong, KDD ATAS, KDD BAWAH in the map) were selected in Meninting (Fig. 2); and three subvillages including two along the coast (Lab Bua, Bina Marga including Batu Rea) and one in the forested area (Seseng) were selected in Utan (Fig. 3) as sites for the longitudinal parasitological surveys. In advance, all the households in each subvillage were listed and the location of each house marked on a map of the subvillage by health center staff with the cooperation of the head or other influential persons in each subvillage. Based on these household surveys and map, randomly selected villagers were enrolled as

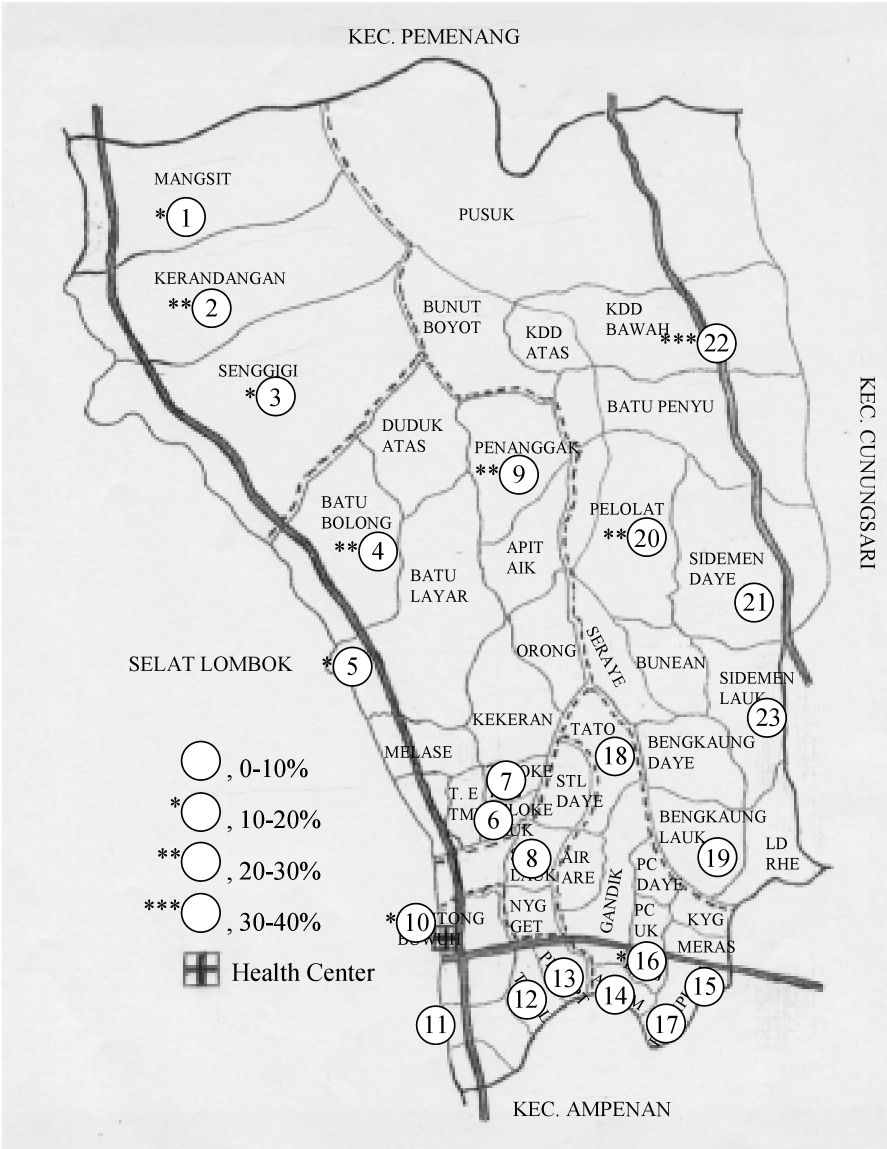

Fig. 2. Distribution of subvillages in Meninting area, and location of elementary schools. The number in each circle shows a school number. Number of asterisks on each circle shows a range of spleen rate. Subvillages including school No. 2, 5, 10 and 22 were selected for regular surveys.

subjects in the parasitological surveys involving a medical examination by a physician and collection of thick and thin blood films from a finger prick blood sample. To determine the transmission season and areas of endemic malaria, the same subjects were followed throughout the project period. Regular surveys including the following activities were carried out once every three months .

A). Registration. Staff from the health center and district health office, with the cooperation of subvillage heads, prepared an individual chart for each villager, explaining the purpose of the survey and obtaining consent from each subject to undergo medical and periodic blood examinations throughout the duration of the project.

B). Medical examination. Each villager was examined and the medical history recorded by a medical doctor, who prescribed medications when necessary and appropriate on the basis of thorough physical findings.

C). Blood examination. Using sterile techniques, thin and a thick blood films from each subject were prepared on separate glass slides using a finger prick. If malaria infection was suspected, the rapid whole blood immune-chromatographic test (ICT NOW® MALARIA, Binax, USA) was applied for quick diagnosis.

D). Check out. All villagers received a reminder about the

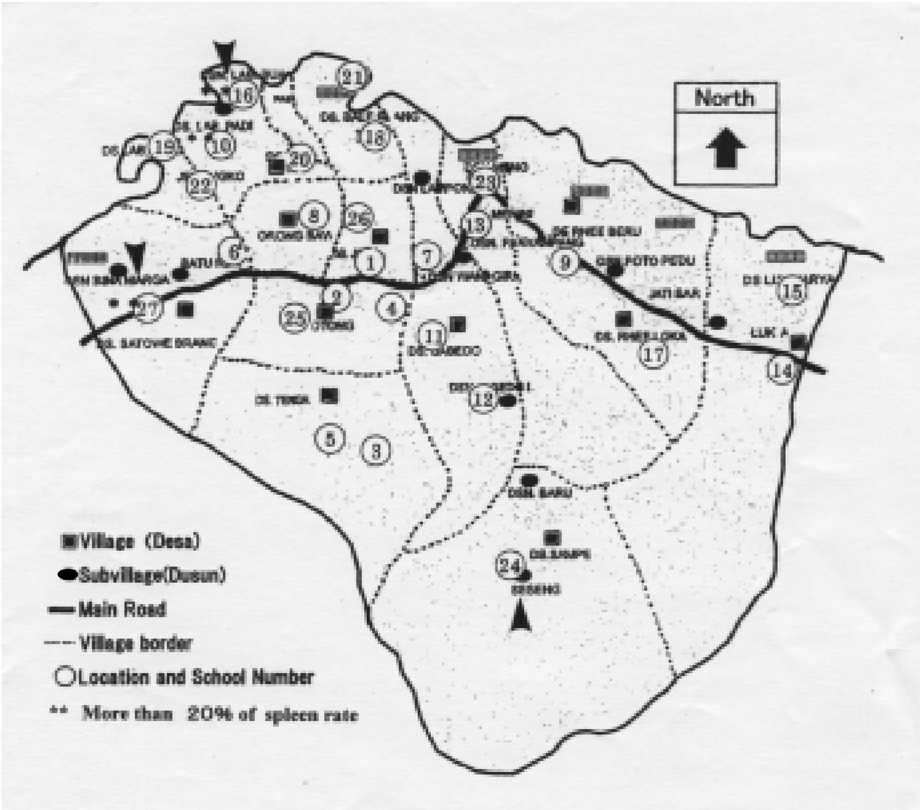

Fig. 3. Distribution of subvillages in Utan area and location of elementary schools. Three schools (**) had a spleen rate of higher than 20% but all the others were less than 10%. Subvillages (shown by arrowheads) including school No. 16, 27, and 24 were selected for regular surveys.

date of the next survey and instructions on how to minimize the risk of becoming ill with malaria.

4. Case Detection and Treatment. In the two health centers, field malaria surveying teams were set up to identify villagers who were sick with malaria and to treat them promptly with the appropriate antimalarial regimen. Visiting teams were organized for purposes of persistent detection and treatment of malaria patients. This activity aimed to reduce sources of malaria parasites. One team consisted of two members. Three to 5 teams were formed in each health center. Except for a few regular staff members who acted as coordinators, the members were newly hired graduates of nurse training schools. In the Meninting area, they prepared schedules for visits to subvillages in the area, initially to all subvillages but later only those with endemic malaria. The schedules were given to the heads or influential persons of subvillages, who passed them on to villagers with instructions to gather at an appointed place and time if they had experienced fever, shivering, headache and other signs of malaria within a week. The team prepared a chart for a patient in which necessary matters were filled out, and then examined blood using the ICT. At the same time the team made two blood films (thick and thin smears) and gave medicine to ICT positive patients according to the directions by the ministry of health. When a patient provided informed consent, two drops of blood were collected onto a filter paper for analysis of chloroquine resistance related genes [5]. In the Utan area the activity of case detection and treatment was concentrated in three important subvillages, dusun Bina Marga (including Batu Rea), dusun Lab Bua and dusun Seseng. Instead of wide coverage, the follow-up of treated patients was conducted intensively to examine the efficacy of administered drugs.

5. Statistical analysis. Age dependence to *P. f.* and *P. v.* infection was comparatively examined using Wilcoxon's rank sum test.

6. Ethical consideration. 1) Informed consent was obtained from all adult participants and from the parents or legal guardians of minors. 2) This study was approved as appropriate by the Ethical Committee of the Institute of Tropical Medicine, Nagasaki University, Japan (02070501).

Table 1. The results of spleen examination of school children in low grades of elementary school in Meninting area.

GC	School No.	Name of School	No. Examined	Positive No.	Spleen Rate
FH	9	SDN KEKERAN	48	14	29.2%
	20	SDN 2 BENGKAUNG	27	6	22.2%
	22	SDN KEDONDONG	45	15	33.3%
C+FH	4	SDN 4 BATULAYAR	59	12	20.3%
	5	SDN 1 BATULAYAR	121	21	17.4%
C	1	SDN KERANDANGAN	56	10	17.9%
	2	M I KERANDANGAN	45	9	20%
	3	SDN SENGGIGI	109	15	13.8%
	10	SDN MONTONG BUWUH	102	11	10.8%
C+RF	11	SDN 2 MENINTING	68	2	2.9%
RF+FH	18	SDN 5 TATO	67	0	0%
	19	SDN 1 BENGKAUNG	156	0	0%
	21	SDN SIDEMEN	55	0	0%
	23	M I SIDEMEN	29	1	3.4%
RF	6	SDN 3 BATULAYAR	58	1	1.7%
	7	SDN 2 BATULAYAR	125	2	1.6%
	8	SDN 3 MENINTING	65	0	0%
	12	M I TEGAL	43	0	0%
	13	SDN 1 MENINTING	79	3	3.8%
	14	SDN 1 SANDIK	87	1	1.1%
	15	SDN 2 SANDIK	92	1	1.1%
	16	SDN 3 SANDIK	76	15	19.7%
	17	SDN 4 SANDIK	91	0	0%
		Total	1,703	139	8.2%

GC, geographical character; FH, forested hill; C, coast; RF, rice field.

RESULTS

1. Spleen examination

1) As shown in Table 1 and Fig. 2 higher spleen rates were found among school children in the northern Meninting area, especially inner hilly forested places (school No. 4, 9, 20 and 22), although prior to the spleen examination we had determined that endemic malaria in this area was distributed along the coast due to transmission vectors breeding in lagoons. Endemic malaria along the coast seemed to be suppressed at less than 20% of spleen rate except for school No. 2. In the southern Meninting area with developed paddy fields and the densest population , there was virtually no malaria endemicity. The distribution of schools shown in Fig. 2 also reflects the population pattern.

2) In Utan area of Sumbawa, only three schools located along the coast had a spleen rate over 20% ; all the others were less than 10% (Table 2, Fig. 3).

2. Regular survey

1) On the basis of the results of spleen examination in the Meninting area, dusun (subvillage) Kedondong, dusun Kerandangan, dusun Montong Buwuh and dusun Batulayar were selected for the regular survey (Fig. 2). The results from February 2002 to December 2003 are shown in Table 3. Among the four subvillages Kedondong in the forested hill area showed a constant positive rate, while the other subvillages along the coast showed an unstable low positive rate. Kedondong is geographically separated into two parts, i. e., Kedondong Atas (KDD ATAS) located nearly at the top of the hill Kedondong (589m), and Kedondong Bawah (KDD BAWAH) on the foot of the hill. Most of the malaria cases were found at Kedondong Atas.

2) In the Utan area three subvillages were selected, namely, two from the coast and one from the inner hilly area. Rather high slide-positive rates were found in the coastal subvillage Bina Marga including Batu Rea, but only one *Plasmodum falciparum* (*P. f.*) patient was found in the hilly inner subvillage Seseng throughout the year (Table 4).

3. Case detection and treatment

1) In the Meninting area most of the malaria cases were detected in hilly forested subvillages,with the exception of subvillage Kerandangan at the 8th position (Table 5 and Fig. 4),despite the fact that less than one seventh of the popula-

Table 2. The results of spleen examination of school children in low grades of elementary school in Utan area.

GC	School No.	Name of School	No Examined	Positive No	Spleen Rate
C	10	SD LAB PADI	54	12	22.2%
	16	SD LAB BUA	56	16	28.6%
	19	SD LAB BAJO	75	0	0%
	21	SD SEKOKOK	64	3	4.7%
	27	BINA MARGA	60	14	23.3%
C+RF	9	SD RHEE BERU	137	5	3.6%
	15	SD LUK KARYA	72	1	1.4%
	17	SD RHEE LOKA	103	2	1.9%
	18	SD BALE BRANG	53	0	0%
	20	SD PUKAT	51	2	3.9%
	22	SD JERONGKO UTAN	87	5	5.7%
	23	SD MEMO	70	3	4.3%
RF	1	SD 1	113	3	2.7%
	2	SD 2	137	1	0.7%
	3	SD 3	55	2	3.6%
	4	SD 4	111	0	0%
	5	SD 5	96	0	0%
	6	SD 6	74	0	0%
	7	SD 7	137	8	5.8%
	(8	SD 8	55	not done	-)
	11	SD SABEDO II	62	1	1.6%
	12	SD SABEDO I	65	1	1.5%
	13	SD KR TENANG	70	0	0%
	14	SD LUK-A	52	1	1.9%
	25	MI MUHAMMADIYAH UTAN	52	0	0%
	26	MI NURUL HIDAYAH NW UTAN	53	0	0%
RF+FH	24	SD SESENG	48	4	8.3%
		Total	2,007	84	4.2%

GC, geographical character; C, coast; RF, rice field; FH, forested hill.

Table 3. Slide positive rate by regular malaria surveys in Meninting area in 2002 and 2003.

Time of survey	Name of subvillage											
	Kedondong			Kerandangan			Batulayar			Montong Buwuh		
	No. Ex	No. Pos.	Pos. R.(%)	No. Ex	No. Pos.	Pos. R.(%)	No. Ex	No. Pos.	Pos. R.(%)	No. Ex	No. Pos.	Pos. R.(%)
2002 Feb.	101	5(2)	4.0	138	10(3)	6.5	176	0	0	194	0	0
June	80	6(4)	7.5	133	3(3)	2.3	148	0	0	150	0	0
Sept.	135	9(2)	6.0	107	1(0)	1.0	209	5(4)	2.4	138	0	0
2003 Feb.	100	9(4)	9.0	108	0	0	180	3(3)	1.7	210	1(1)	0.5
May	89	8(2)	9.0	105	0	0	214	0	0.0	201	1(1)	0.5
Aug.	123	18(12)	14.6	111	1(1)	0.9	280	1(0)	0.4	205	1(1)	0.5
Dec.	109	6(0)	5.5	113	2(2)	1.8	199	0	0	163	0	0

No. Ex., Number of examined subjects; No. Pos., Number of positive cases; Pos. R., Positive rate; In ( ) number of *Plasmodium falciparum* cases were shown.

tion lives there. The ICT Pf/Pv can differentiate *P. f.* infection including its mixed infection from other types of malaria, particularly *Plasmodium vivax* (*P. v.*) infection. The former was treated as *P. f.* malaria and the latter as *P. v.* malaria according to the malaria treatment guidelines established by the Indonesian government. The final confirmation was done by microscopic observation in the health center. At the outset of this activity from January to March in 2002 microscopic examinations were not conducted because the activity was still in the preparation period, but afterward they were introduced and the specificity and sensitivity of ICT to *P. f.* infection were shown to be 91% and

Table 4. Slide positive rate by regular malaria surveys in Utan area in 2003 and 2004.

Time of survey	Name of subvillage								
	Seseng			Lab Bua			Bina Marga		
	No. Ex	No. Pos.	Pos. R.(%)	No. Ex	No. Pos.	Pos. R.(%)	No. Ex	No. Pos.	Pos. R.(%)
2003 Jan.	175	0	0	147	6(4)	4.1	135	22(18)	16.3
May	114	0	0	161	3(3)	1.9	134	23(15)	17.2
Sept.	132	1(1)	0.8	148	1(1)	0.7	220	27(14)	12.3
Dec.	132	0	0	111	1(0)	0.9	182	12(9)	6.6
2004 March	105	0	0	130	1(0)	0.8	139	7(4)	5.0

No. Ex., Number of examined subjects; No. Pos., Number of positive cases; Pos. R., Positive rate; In ( ) number of *Plasmodium falciparum* cases were shown.

Table 5. Number of ICT positive cases by subvillages and month in 2002 at Meninting area detected by visiting teams.

No.	Name of Subvillage	Geographical Character	Month											Total	Total Examined	ICT Positive Rate
			JAN	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC			
1	Batu penyu	Forested hill (FH)	6(6)	0	3(3)	10(7)	6(5)	7(5)	11(9)	5(4)	4(4)	2(1)	4(0)	58(44)	89	65.2
2	Duduk Atas	FH	4(1)	7	6(4)	7(5)	1(1)	6(4)	1(1)	11(4)	4(2)	1(0)	0(0)	48(22)	69	69.6
3	Penanggak	FH	9(6)	0	3(3)	6(4)	4(1)	5(3)	7(5)	4(3)	1(1)	1(1)	0(0)	40(27)	79	58.0
4	Kedondong Atas	FH	0	4	2(2)	3(1)	0(0)	8(4)	9(6)	9(2)	3(1)	0(0)	0(0)	38(16)	67	56.7
5	Orong	FH	3(1)	0	6(5)	3(3)	8(6)	3(3)	2(1)	8(5)	0(0)	1(0)	0(0)	34(24)	55	61.8
6	Batubolong	FH	7(7)	5	4(3)	0(0)	1(1)	1(1)	4(3)	6(5)	0(0)	0(0)	0(0)	28(20)	35	80.0
7	Peloat	FH	4(3)	1	7(6)	7(3)	4(3)	0(0)	2(2)	1(1)	1(0)	0(0)	0(0)	27(18)	46	56.7
8	Kerandangan	Coast	6(6)	2	1(1)	3(3)	1(1)	0(0)	1(1)	0(0)	1(0)	2(0)	0(0)	17(12)	45	37.8
9	Bunean	FH	3(3)	0	0(0)	3(3)	5(5)	3(2)	1(1)	1(0)	0(0)	0(0)	0(0)	16(14)	24	66.7
10	Apit Aik	FH	1(0)	0	0(0)	3(1)	0(0)	9(4)	2(0)	0(0)	1(1)	0(0)	0(0)	16(6)	26	61.5
11	Tato	FH+Field	1(1)	0	(3)1	5(4)	3(2)	0(0)	1(1)	0(0)	0(0)	0(0)	0(0)	13(9)	24	54.2
12	Batulayar	FH+Coast	2(1)	1	0(0)	0(0)	1(1)	2(1)	1(1)	1(0)	3(3)	1(1)	0(0)	12(8)	30	40.0
13	Sidemen Lauk	FH	2(2)	0	1(1)	1(1)	0(0)	6(5)	0(0)	1(0)	0(0)	0(0)	0(0)	11(9)	19	57.9
14	Seraye	FH	0	0	0(0)	0(0)	0(0)	7(4)	0(0)	0(0)	2(2)	2(1)	0(0)	11(7)	26	42.3
15	Kedondong Bawah	FH	0	0	1(1)	0(0)	0(0)	0(0)	3(2)	0(0)	2(1)	1(1)	3(1)	10(6)	19	52.6
16	Mangsit	Coast	0	3	1(1)	2(0)	1(0)	1(0)	0(0)	1(1)	0(0)	0(0)	0(0)	9(2)	32	28.1
17	Melasa	Coast	0	2	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	4(3)	7(4)	19	36.8
18	Sidemen Daye	FH	0	0	0(0)	0(0)	0(0)	4(2)	0(0)	2(0)	0(0)	0(0)	0(0)	6(2)	20	30.0
19	Pusuk	FH	1(0)	0	2(2)	0(0)	0(0)	0(0)	1(1)	1(1)	0(0)	0(0)	0(0)	5(4)	8	62.5
20	Seteluk Daye	FH+Field	0	0	0(0)	2(0)	1(1)	0(0)	0(0)	0(0)	0(0)	1(1)	0(0)	4(2)	12	33.3

In ( ), the number of *Plasmodium falciparum* cases was shown.

95%, respectively (data not shown). There was no special transmission season, but in general, higher transmission was seen in the dry season from March to September. From the beginning of the rainy season the transmission seemed to decline and almost cease at the peak of the rainy season but to recover again at the end of the rainy season on January. Patients were found at most of the hilly forested subvillages but the number of detected patients varied widely among subvillages and months. This might be due to different environmental and social conditions among subvillages and to the great difficulty encountered in communication between each of them. In the coastal subvillages, more than 10 patients were found only in subvillage Kerandangan in the northernmost part of Meninting area. ICT positive rates in examined persons were more than 60% on average in subvillages on forested hills from No. 1 to No. 10 (Table 5) but less at subvillages on the coast. The same tendency was also found in Utan, i.e., the more than 60% accuracy of clinical diagnosis dropped after the successful control (Table 6). This indicated that clinical diagnosis of malaria was reliable in more than half of suspected patients only under meso-endemic conditions seen here. Over 60% of malaria patients were infected with *P. f.*, the rest being mainly *P. v.* and a small number of *P. malariae*. The definite mixed infection with *P. f.* and *P. v.* was seldom found because it was confirmed only by microscopic observation in the present study and not by ICT. Usually, the microscopist in a health center did not search eagerly for a mixed infection after detecting a dominant species of parasite. Mostly, children less than 11 years old were affected by both *P. f.* and *P. v.* malaria (Fig. 5), and malaria cases decreased with increasing age. Why higher cases of *P. v.* malaria were found at the age of 0 is unknown, but the tendency of earlier exposure to *P. v.* in younger age was demonstrated (P=0.033).

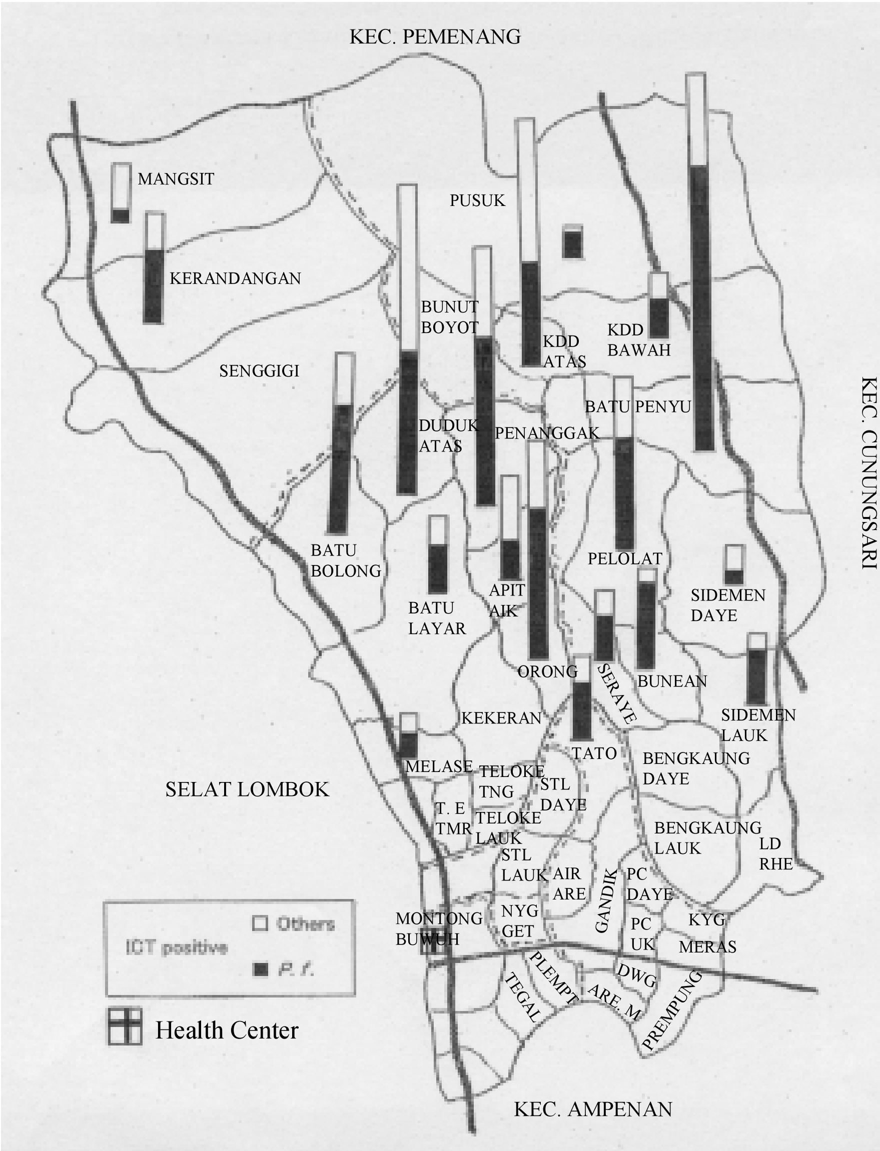

Fig. 4. Number of detected cases with ICT in each subvillage in 2002.

2) In the Utan area, three teams for case detection and treatment were organized and undertook the same work in the three selected subvillages for the regular survey. In subvillage Seseng located in the hilly area, the teams could not find patients, and therefore only the results from subvillage Bina Marga, Batu Rea and Lab Bua are shown in Table 6. Around 70% of malaria cases were of *P. f.* In subvillage Bina Marga and Butu Rea, the peak age group of malaria cases was from 6 to 10, while in subvillage Labu Bua the number of malaria cases showed a gradual increase till the age group 16 to 20 and a gradual decrease after that. This indicates earlier acquisition of immunity due to higher endemicity in the former two subvillages (Fig. 6). In Bina Marga and Batu Rea, cases of *P. f.* and *P. v.* by age group are shown comparatively in Fig. 7. *P. vivax* infection is prone to occur earlier in the younger age group as seen in the Meninting area (P=0.007). The follow-up showed that the rate of unsuccessful cure for *P. f.* malaria after five days was 50.4% for chloroquine treatment (Table 7) and 41.5% for sulfadoxine-pyrimethamine (SP) compound (Table 8). Although a high proportion of patients were not cured after five days of treatment, we did not find any severe complicated cases at that point. We were not able to conduct observations any longer than 5 days because of the regulation of malaria therapy in Indonesia and for ethical reasons.

DISCUSSION

We had the opportunity to conduct a malaria control project in small areas of two islands in Indonesia, i.e. Lombok and

Table 6. Slide positive cases by the case detection activities in Utan area in 2003.

Month	BINA MARGA			BATU REA			LAB BUA		
	No. Ex.	No. Pos. (P. f.)	Pos. R. (%)	No. Ex.	No. Pos. (P. f.)	Pos. R. (%)	No. Ex.	No. Pos. (P. f.)	Pos. R. (%)
Feb.	60	34 (29)	56.7	27	17 (14)	63.0	38	19 (16)	52.5
Mar.	41	30 (23)	73.2	12	9 (6)	75.0	36	15 (10)	41.7
Apr.	32	21 (15)	65.6	13	6 (6)	46.2	14	7 (5)	50.0
May	30	22 (15)	73.3	9	6 (3)	66.7	6	2 (1)	50.0
June	43	24 (17)	55.8	16	8 (3)	50.0	11	3 (1)	30.0
Jul.	25	6 (4)	23.1	12	3 (1)	25.0	9	2 (1)	22.2
Aug.	15	8 (6)	53.3	18	7 (4)	38.9	4	4 (4)	
Sept.	22	6 (4)	22.2	14	4 (3)	28.6	4	2 (1)	
Oct.	6	4 (3)		6	2 (0)		2	0	
Nov.	4	1 (1)		6	0 (0)		0	0	
Dec.	5	1 (0)		1	1 (1)		13	1 (0)	

No. Ex., Number of examined subjects; No. Pos., Number of positive cases; Pos. R., Positive rate; In ( ), number of *Plasmodium falciparum* cases were shown.

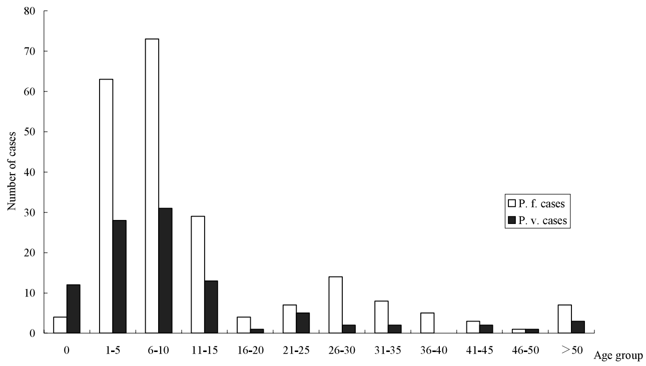

Fig. 5. Number of falciparum and vivax malaria cases by age group in Meninting area found by visiting teams with ICT.

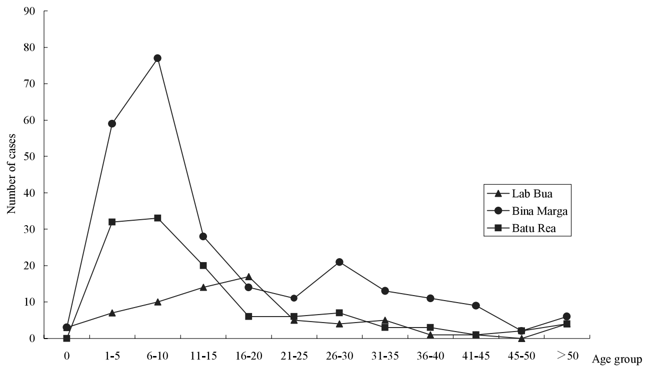

Fig. 6. Number of malaria cases by age group in three subvillages of Utan area microscopically found by visiting teams.

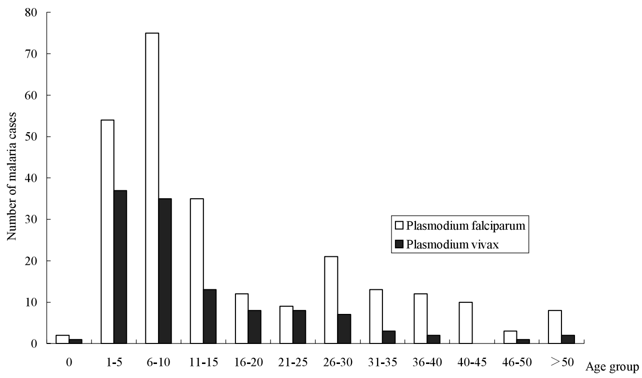

Fig. 7. Number of falciparum and vivax malaria cases by age group in Bina Marga (including Batu Rea) found microscopically by visiting teams.

Sumbawa island, for a period of three years from November 2001 to October 2004. Malaria endemic areas in the two islands had been believed to be distributed mainly in coastal areas [2] where important bleeding sites for vector mosquitoes such as lagoons and fish-ponds were scattered. In fact the data initially submitted by the local health offices demonstrated a high prevalence of malaria patients along the coast. Owing to the time limitation, epidemiological, entomological and control works were launched in parallel. Firstly, to understand the distribution of malaria endemic foci quickly but roughly, the spleen rates of school children in lower grades of all the elementary schools were examined [3, 4]. The results demonstrated that in the two project areas hypo- to meso-endemic subvillages were scattered in the two project areas, i. e., in Meninting area higher spleen rates were observed in hilly forested areas rather than coastal areas (Table 1, Fig. 2), while in Utan area they were observed in some coastal places (Table 2, Fig. 3). The higher malaria endemicity in forested subvillages of Meninting area was an unexpected new finding. This finding was confirmed by the subsequent activity of case detection and treatment (Table 5, Fig. 4), indicating the usefulness of the spleen examination in school children to quickly deter-

Table 7. Plasmodium falciparum sensitivity to chloroquine treatment after 5 days of administration in Utan area.

Dusun	No. of treated	No. of cured(%)	No. of still positive(%)	No. of no follow-up
BINA MARGA	157	48(30.6)	68(43.3)	41(26.1)
LAB BUA	45	10(22.2)	27(60.0)	8(17.8)
BATU REA	63	17(27.0)	38(60.3)	8(12.7)
SESENG	3	1(33.8)	2(66.7)	0
Total	268	76(28.4)	135(50.4)	57(21.3)

No. of treated, number of treated patients; No. of cured, Number of slide-negative patients with *P. f.* ring forms 5 days after treatment; No. of still positive, number of still slide-positive patients with *P. f.* ring forms 5 days after treatment; No. of no follow-up, Number of patients who escaped from follow-up.

Table 8. Effect of SP against falciparum malaria used as a second line of antimalarial drug in Utan area.

Subvillage	*No. of administered	**No. of cured(%)	**No. of still positive(%)	No. of no follow-up(%)
BINA MARGA	61	18(29.5)	23(41.0)	18(29.5)
LAB BUA	31	5(16.1)	17(54.8)	9(29.0)
BATU REA	38	10(26.3)	12(31.6)	16(42.1)
Total	130	33(25.4)	54(41.5)	43(33.1)

* Patients who were not cured by chloroquine administration after five days were given sulfadoxine-pyrimethamine (SP). ** Usually blood examination was done 4-10 days after SP treatment.

mine the endemic situation in a malaria endemic area where hypo- to meso-endemic foci were mixed [3, 4]. Secondly, the regular surveys and activities of case detection and treatment were launched simultaneously. The former was initially aimed at determining the transmission season by the follow-up study of the same subjects but did not yield any useful information for the following reasons (Table 3, 4): 1) case detection and treatment launched simultaneously worked effectively, especially in coastal subvillages: 2) distribution of impregnated mosquito nets, started in Utan area with a delay of only 4 months , also worked effectively; and 3) the regular survey scheduled for December 2002 in Meninting area was canceled due to road destruction by heavy rain. However, the villagers welcomed the activities because they were accompanied by medical services, and they provided excellent cooperation in the the control activities.

Meanwhile, the continuous activity of case detection and treatment was shown to be very useful for understanding epidemiological conditions as well as for malaria control. Since the activity needed only motor-bikes and strong legs, it was continued without interruption (except the Ramadan period) even in the rainy season. The results showed that in Meninting area most malaria patients were found in forested hills with less than a seventh of the total population (Table 5, Fig. 4). Moreover, there was no common transmission peak among subvillages in forested hills although transmission was more active in the dry season, and the heavy rain from October to December seemed to interrupt malaria transmission. The entomological survey revealed that *Anopheles balabacensis* was the primary vector in forested hills and *Anopheles sundaicus* along the coast (in preparation for publication). Anopheles balabacensis has been reported as the primary vector in east Kalimantan and in some parts of Java [1, 6, 7]. At the latter, *Anopheles maculatus* played the major role in malaria transmission together with *An. balabacensis* [7]. According to these reports, *An. balabacensis* is more common during the wet periods. This tendency is not applicable to the same species of mosquito in the forest of Meninting, where most malaria patients were found during the dry periods. Of course, this can be explained by the fact that breeding water pools in the hilly forest are washed away by heavy rain. But, on the other hand, the common decrease in malaria cases at all the subvillages in the forest after October 2002 is also thought to be caused by the continuous activity of case detection and treatment. In the coastal area of Meninting, the typical transmission pattern by *An. sundaicus* [2, 8] was not determined owing to the scanty number of patients. In Utan area almost all the patients were found in coastal subvillages (Table 2, 4). The main transmission vector was determined as *Anopheles subpictus* (in preparation for publication), the breeding sites of which were revealed to be mainly fishponds developed and abandoned in mangrove forests [2]. Although our results showed a higher transmission in the late wet season, the transmission situation in other seasons was not clarified due to the successful control measures and the small fluctuation of density of adult mosquitoes and larvae. In the present activity for case detection, we used the ICT diagnostic kit to administer immediate complete treatment. This also made it possible to evaluate the accuracy of clinical diagnosis on the basis of several symptoms. In the meso-endemic subvillages or on the condition that several malaria patients always appeared, over 60% of clinical diagnosis for malaria was shown to be correct (Table 5, 6), but in the hypo-endemic villages, few of the suspected cases were found to suffer from malaria. Therefore, the accuracy of clinical diagnosis declined with the progress of the control works (Table 6). Although the ICT diagnostic kit is very expensive, it is a very powerful tool, especially in remote endemic areas where there is no means of transportation except on foot. In such endemic places, standard methods for examining chloroquine resistance of *P. f.* parasites such as the follow-up study of treated patients (in vivo test) and *P. f.* parasite culture (in vitro test) are impractical. Therefore we applied the analysis of chloroquine-resistance related genes [5] and found 100% mutation in *pfcrt* and about 50% mutation in *pfmdr*. The interesting point was that mutations in *pfcrt* were mostly Papua New Guinea type and only a small number of South Asian type. In Utan area the follow-up study of chloroquine- treated patients was facilitated by motor-bikes. Although complete follow-up for 28 days was not achieved, a high proportion of *P. f.* patients showed ring -form positive after 5 days of treatment by both chloroquine and SP (Table 7, 8). This indicated that drug-resistant *P. f.* parasites are prevalent in the area, but a higher grade of resistance over RII level was not found, judging from the clinical symptoms and the microscopic examination five days after treatment. This was consistent with the report in Lombok [9]. The problem was that we could not confirm drug compliance by the patients.

The results of spleen examination and regular surveys indicated that the malaria endemic level in our areas was from hypo-endemic to meso-endemic. Clinical immunity to malaria has been known to be acquired by natives at a young age owing to repeated infection in hyper-endemic area, but not in meso- or hypo-endemic areas, resulting in almost equal prevalence of symptomatic malaria in people of all ages [10, 11]. But the present results showed that malaria cases declined steadily after 10 years of age (Fig. 5, 6, 7). However, this tendency was not seen in the low endemic (probably hypo-endemic) subvillage Labu Bua (Fig. 6). Malaria patients were detected by ICT among suspected cases on the basis of symptoms. This indicated that most detected patients were symptomatic. These results were quite different from the traditional assumption but might be consistent with the recent reports about rapid acquisition of protective immunity with increasing age [12] and quick acquisition of clinical immunity to non-cerebral severe malaria [13]. The traditional assumption came from epidemiological data mainly in Africa, but one of the new ideas came from those in Indonesia. Other plausible reasons may be the difference in diversity of species and strains of malaria parasites, and in transmission mode and intensity between them. A tendency of early exposure to *P. vivax* malaria observed in the both areas was also observed in Vanuatu [4, 14]. The reason is unknown ,but at least it is recognized that acquisition of clinical immunity is prone to be earlier against *P. vivax* [4, 15].

Overall, even in small malaria endemic foci in Lombok and Sumbawa island, epidemiological situations differed widely according to environmental and socio-economical conditions. So far, the attention of official health organs has been concentrated on major residential areas due to lack of manpower. Now, endemic malaria is known to be distributed mainly in remote forested and coastal areas. Originally, residents there had been isolated from the general economic activity, but recent economic and social development has urged them to work outside their villages. This means that human malaria sources are easily carried outside and therefore that the malaria epidemiological study should be done in remote and inconvenient villages to achieve successful malaria control. Identifying and understanding the influence of these population movements can improve prevention measures and malaria control programs.

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