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EFFECTS OF IMMIGRATION ON THE PREVALENCE OF MALARIA IN RURAL AREAS OF THE AMAZON BASIN OF BRAZIL

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Epidemiological studies were conducted on malaria in three rural areas of the Amazon basin in the State of Rondônia: the town of Costa Marques, Forte Príncipe da Beira (Fort), and an immigrant settlement in the nearby forest. These studies were instituted to document the malaria problem and to describe the role of immigration on its distribution and prevalence. Hospital records in the town show that the number of malaria cases increased five fold from 1983 to 1987 and that the predominant malaria parasite changed from Plasmodium vivax *to* P. falciparum. *Increased malaria followed increased immigration and colonization of the forest. A series of epidemiologic studies suggested the linkage between malaria and immigration as the prevalence of malaria was 1-2% at the Fort, a stable community, 8-9% at Costa Marques, a growing community, and 14-26% in the new settlements in the forest.*

Key words: malaria – epidemiology – Brazil

Human malaria in Brazil is caused by *Plasmodium falciparum, P. vivax*, and, on rare occasions, by *P. malariae*. Over 99% of the malaria cases are reported from the Amazon region where its incidence is increasing (Fig. 1) (Deane, 1988). This increase is linked to the mass immigration of poor people from non-endemic regions of Brazil to the Amazon basin (Marques, 1986, 1987; Pinheiro, 1985; Vesiland & Maze, 1987). In these remote areas, the transmission of malaria is facilitated by poverty, inadequate housing, insufficient health education, logistic difficulties, inadequate mosquito control, and an overwhelmed health service. Malaria control is further complicated by a high frequency of drug resistant falciparum malaria (Reyes, 1981; Reyes et al., 1985; Alecrim, 1986; Alecrim et al., 1986; Boulos et al., 1986; Rosario et al., 1986). The present paper describes some aspects of malaria transmission in the Costa Marques area of the Amazon jungle.

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MATERIALS AND METHODS

Study site – Our study was focused on three neighboring areas in the State of Rondônia (12°22'S, 64°14'W): the town of Costa Marques, the small military community of Forte Príncipe da Beira (Fort) and the immigrant settlement along road BR429 (Fig. 2). The land is relatively flat and covered by a tropical semi-evergreen seasonal forest (Beard, 1944). Annual rainfall data recorded at the Fort from 1984 to 1986 were 147 cm, 178 cm and 127 cm respectively. Rainfall was distributed into a dry season from May to September and a wet season from October to April.

Until recently Costa Marques was linked to the outside world only by the Guaporé river. In late 1985 immigration was facilitated by the completion of a paved airport and a dirt road (BR429) to Presidente Médici. Immigrants to the area settle in deforested areas on the perimeter of the town and in the forest along BR429.

Malaria surveys – Initial surveys were conducted in October 84 at the Fort and town and again in June 85 in the town to gather information on demography and the prevalence of malaria. Starting in March 86, five quarterly house to house surveys were made in the

pioneer settlement along BR429 from km 8-100 to determine seasonal prevalence rates. During the same period house to house surveys were repeated in the town in September 86 and at the Fort in December 86.

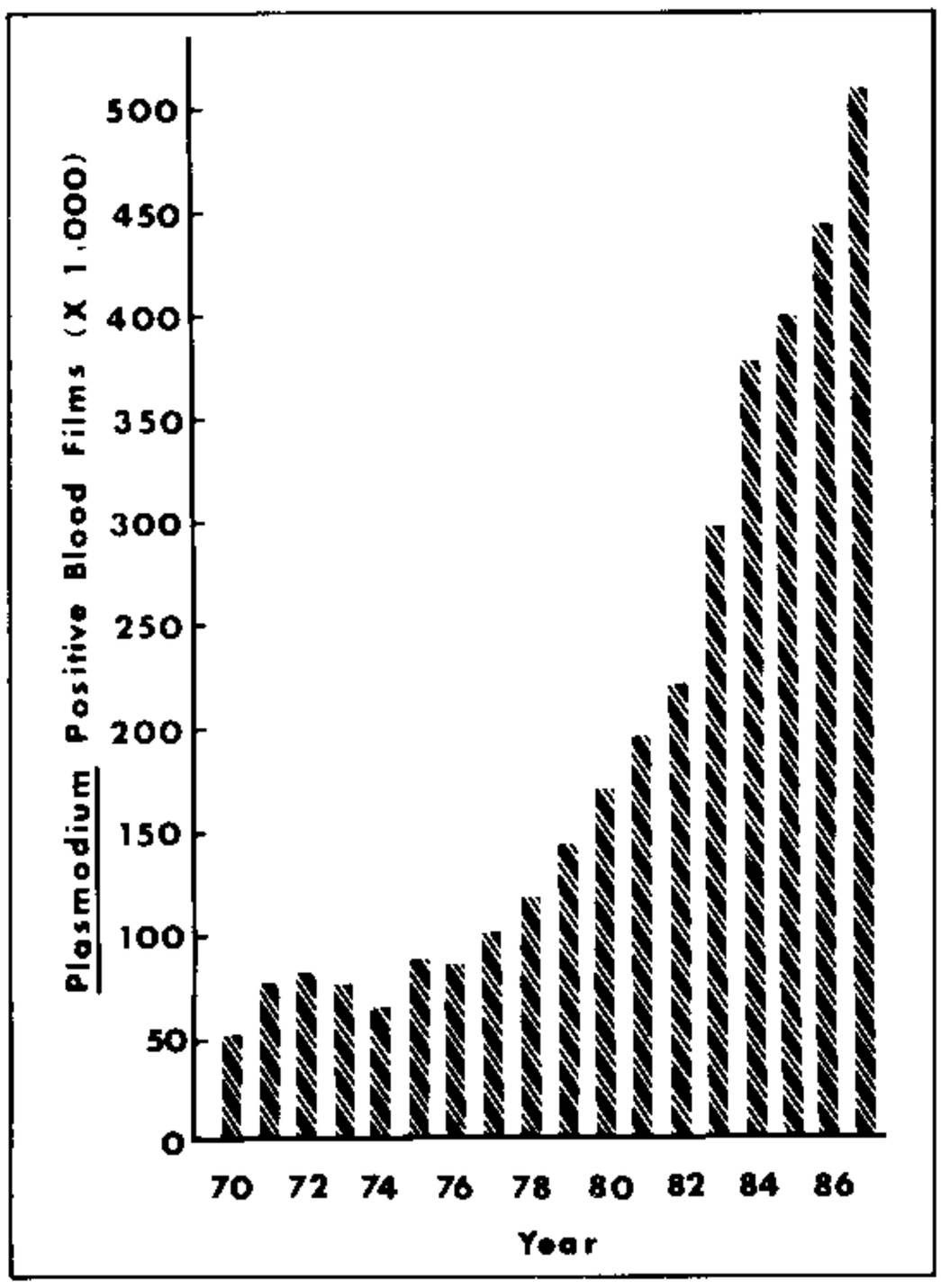

Fig. 1: number of blood films reported positive by SUCAM for malaria parasites from 1970 to 1987 in Brazil. (Data reproduced with permission of SUCAM).

Demographic, clinical and parasitologic data were collected on each survey. Demographic data included name, sex, birthplace, birthday and date of arrival in the study area. The number of malaria episodes during the three month period between our quarterly surveys was estimated from interviews. The proportion of people with asymptomatic parasitemia was determined in a sample of 879 pioneers who were examined during the September and December 86 surveys for signs and symptoms compatible with malaria including fever, headache, malaise, anemia and splenomegaly. The size of the spleen was determined by palpation in the prone position. Parasite rates were determined from thick films prepared from finger prick blood and stained with Giemsa. Diagnoses were based on the examination of 100 thick film fields read at 1000x. Patients with malaria were given appropriate treatment.

Malaria treatment and control programs – For the treatment of malaria the people depend on free clinics in the town of Costa Marques and at the Fort. Treatment is also available at two private clinics and at pharmacies where anti-malarial drugs are dispensed without a physician's prescription.

To control malaria the Superintendency for Public Health Campaigns (SUCAM) sprayed the walls of all houses biannually with 2 gm DDT/ m^2. In addition, SUCAM sprayed malathion in the town using an ultra-low volume spray technique on two occasions in October 86 from 1800-2000 hrs which are peak periods of mosquito activity. A mass chemotherapy program was conducted in October, November, and December 86 to curb the increase and spread of malaria. Our observations on this program will be presented elsewhere.

RESULTS

Demography – The communities in the town, Fort, and along BR429 are composed of family units. The majority of people are young as 56% of them were under 20 years old (Table I).

TABLE I

Age distribution of people living in the town of Costa Marques (Jan 86), the Fort (Dec 86) and along BR429 (Mar 87)

Age	Town		Fort		GR429	
	No.	%	No.	%	No.	%
< 5	338	14	63	18	44	13
5-9	418	18	63	18	70	20
10-14	325	14	52	15	57	16
15-19	261	11	35	10	21	6
20-29	391	16	53	15	54	15
30-39	283	12	37	10	44	13
40-49	182	8	23	7	27	8
50-59	101	4	36	3	19	5
⇒60	88	4	17	5	15	4
Total	2387*		355		351	

* Birthdates were available for 2,387 of the 2,901 people registered.

The population at the town is growing. Senior citizens claim that there were 300 people in 1976 while we registered 2,901 people during our house to house census in January 86. This population is unstable as 45% of the registered people could not be found 15

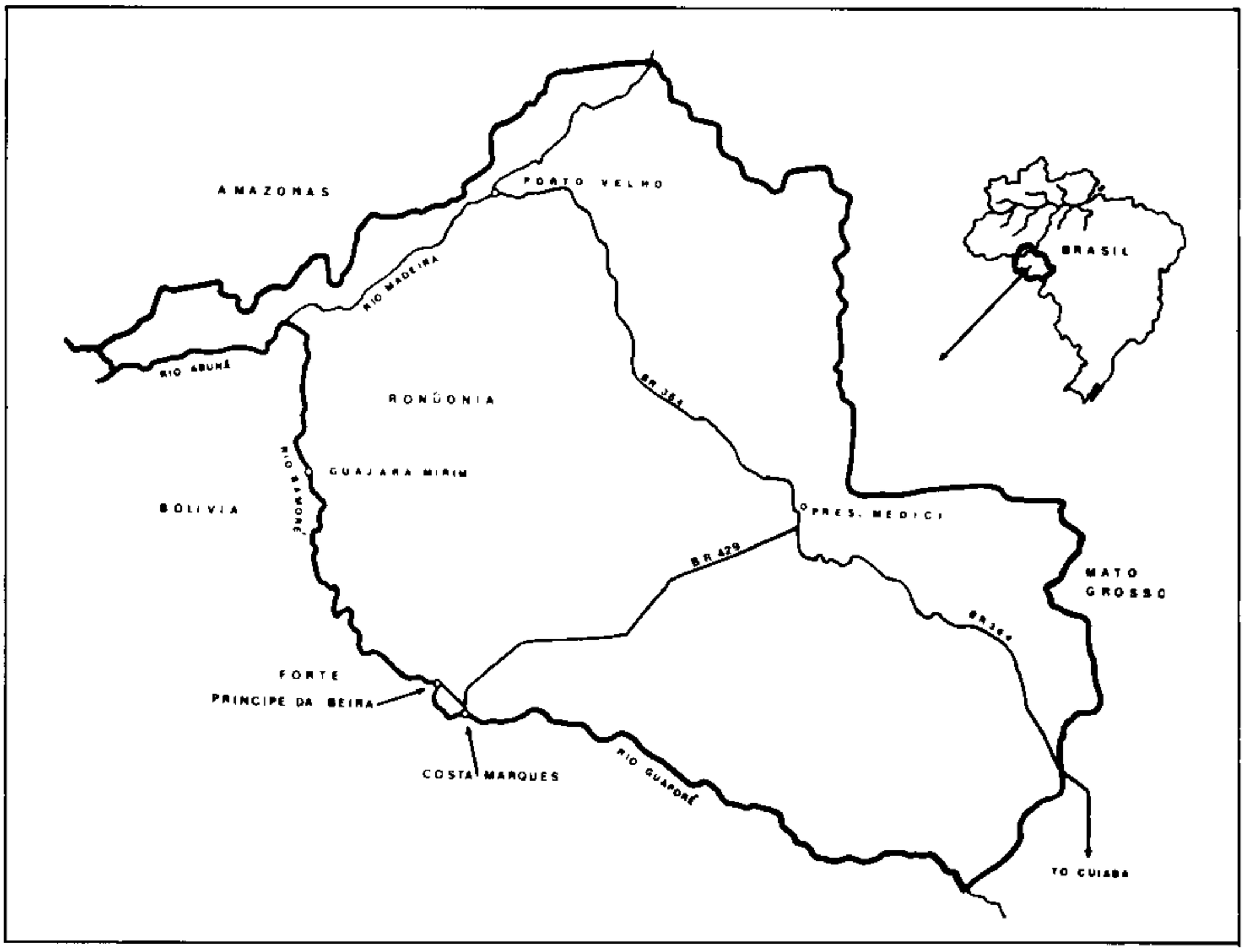

Fig. 2: map of the study area showing the town of Costa Marques, Forte Principe de Beira, and road BR429.

months later in a second census. According to the January 86 census, only 37% of the people were born in the area of Costa Marques. The median month of arrival for the immigrant population was March 80.

The community at the Fort is stable because its population is controlled by the Brazilian army. Although its population decreased from 401 to 355 people from October 84 to December 86, there were 325 permanent residents who lived there the entire 26 month period. According to our December 86 census, 51% of the population was born at the Fort and an additional 40% was born in other parts of Rondônia. The median month of arrival for immigrants to the Fort was November 74.

Colonization of the forest and growth of the pioneer population followed the construction of BR429. According to our March 87 survey, there were 351 residents between km 15-100. Only 10% of them were born in the area. The median month of arrival for the immigrants was August 84. There was a marked population turnover as 63% of a sample registered in the March 86 census were not found in the March 87 census.

Malaria endemicity – The SUCAM at Costa Marques records the number of blood films positive for *P. falciparum* and *P. vivax* each month (Fig. 3). The number of positive films for each 12 month period from May 83 to April 87 was 3,125, 4,612, 5,876 and 16,527. These numbers are underestimates as an unknown number of people seek treatment in the private sector. This increase in the number of cases was related to immigration rather than an increase in prevalence. Data from our surveys show that the prevalence of malaria during this same period ranged from 1-2% at the Fort, 8-9% in the town, and 14-26% along BR429 (Table II).

During this same period, the ratio of falciparum to vivax positive films at the clinic changed from 1:2 to 1:1. The ratio of falciparum to vivax in all of our surveys was 2:1.

TABLE II

Prevalences of malaria parasitemia and splenomegaly in people living in the town of Costa Marques, the Fort and along BR429

Place	Date	Parasitemia – all ages			Splenomegaly			
		No. exam.	Percent		2-10 yrs		> 11 yrs	
			falciparum	vivax	No.	%	No.	%
Town	Oct 84	411	2	6	153	17	218	16
Town	Jun 85	455	6	3	176	22	230	23
Town	Sep 86	210	6	2	67	42	121	33
Fort	Oct 84	371	1	1	131	1	209	0.5
Fort	Dec 86	292	1	0	94	13	104	33
BR429	Mar 86	358	8	6	105	40	229	18
BR429	Jun 86	472	9	7	140	42	280	22
BR429	Sep 86	542	17	9	155	57	334	40
BR429	Dec 86	345	18	3	95	67	193	59
BR429	Mar 87	308	16	5	86	50	159	32

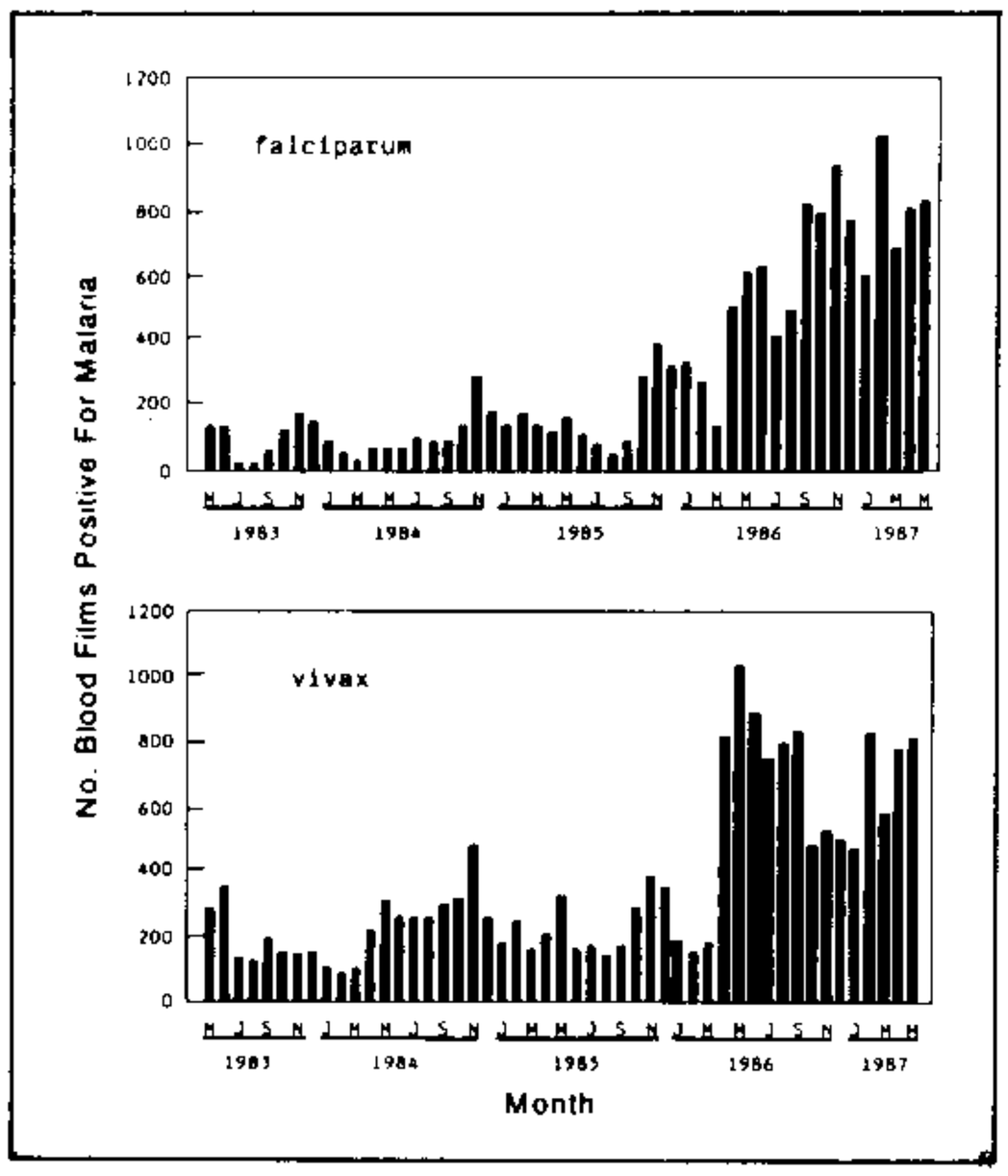

Fig. 3: number of blood films positive for *Plasmodium falciparum* and *Plasmodium vivax* at the SUCAM clinic in Costa Marques. Mixed infections, which represent 0.5% of the malaria cases, are excluded. (Data reproduced with permission of SUCAM).

The incidence of malaria in the Costa Marques area is unknown. However, data from quarterly interviews of the pioneers in the forest suggest that they averaged three to four attacks of malaria from March 86 to March 87.

Splenomegaly – The prevalence of splenomegaly was low at the Fort and town compared to the pioneer population along BR429 (Table II). Representative data on the distribution of spleen sizes by age are shown in Table III. The prevalence of splenomegaly (= palpable spleens) and the frequency of big spleens (= below the rib border) decreased with age. In people < 15 years old splenomegaly was 53% compared to 37% in older people [$(\chi)^2 = 13$, $P < 0.001$]. In contrast, malaria parasitemia did not decrease significantly with age. Similar conclusions were made when all data from the 5 surveys on the pioneer population were combined.

Symptomatology and infection – The use of clinical manifestations alone to diagnose malaria was not a good indicator of plasmodia infection. We failed to detect clinical malaria in 133 of 190 parasitemic people for a false negative rate of 70%. Conversely, we erroneously judged 22 of 689 aparasitemic people to have clinical malaria for a false positive rate of 3% (Table IV).

Control and Prevalence – Despite the availability of free treatment, the short-term mass chemotherapy program, the biannual application of DDT to houses, and the infrequent spraying of ultra-low volume malathion, the number of malaria cases diagnosed at the clinic in Costa Marques increased dramatically in 1986 and remained high in 1987 (Fig. 3). Evidence from our surveys in the pioneer settlement along BR429 indicates that the prevalence of malaria also increased and remained high during this period (Table II).

TABLE III

Malaria parasitemia and splenomegaly by age in people living along BR429 in September 86

Age	Malaria		Spleen size				
	No. exam.	% pos	No. exam.	Percent*			
				NP	PI	B	BB
< 5	78	12	74	54	30	3	14
5-9	103	21	96	48	32	3	17
10-14	73	29	75	40	32	12	16
15-19	43	23	43	44	47	2	7
20-30	89	28	82	60	33	1	6
30-40	63	35	60	62	27	7	5
40-49	44	30	44	70	16	5	9
> 50	49	14	46	83	11	4	2
Total	542	24	520	56	29	5	10

* NP – Spleen not palpable.
PI – Spleen palpable on deep inspiration.
B – Spleen extends to lower border of rib cage.
BB – Spleen extends below lower border of rib cage.

TABLE IV

Relationship between malaria symptoms and parasitemia in people along BR429 in September and December 86

Blood films	Clinical diagnosis		
	+	–	Total
+	57	133	190
–	22	667	689
Total	79	800	879

DISCUSSION

Malaria is an important cause of illness in the Costa Marques area. SUCAM and the Secretary of Health of Rondônia, minimized malaria mortality through free diagnosis and treatment at the clinic. However, malaria morbidity is out of control as the number of people treated for falciparum and vivax infections at the clinic increased dramatically in 1986 and continues at high levels (Fig. 3). This marked increase in cases is related more to the increase in population from immigration than to an increase in the prevalence of malaria. Our results from 10 surveys conducted from October 84 to March 87 show that the prevalence of malaria in the town and Fort was stable while there was only a marginal increase along BR429 (Table II). In addition, the sharp increase in cases in 1986 followed the completion of road BR429 and the subsequent influx of immigrants (Fig. 3). Finally, our studies on the local distribution of malaria show that it is most common in areas with the greatest number of immigrants (Table II). The Fort is a stable community with little immigration and the prevalence of malaria is very low. The town is expanding and malaria is largely found on the periphery where the immigrants settle (M. S. Tada, Malaria Clinic, Costa Marques). The forest population is composed of recent immigrants and it is also the group with the highest prevalence of malaria. It is concluded that malaria in the Costa Marques area is largely a disease of immigrants.

SUCAM records on the proportions of falciparum and vivax cases treated at the clinic over the past 10 years indicate that the number of falciparum cases increased relative to vivax cases (Fig. 3). The reasons for this change are unknown, but could be related to differential drug susceptibility and selection for resistant *P. falciparum*. Clinical experience in the Costa Marques area indicates that vivax malaria is easily treated with chloroquine while falciparum malaria is resistant to chloroquine and, to a lesser degree, Fansidar.

In Brazil there are two diseases which cause splenomegaly at the population level, schistosomiasis and malaria. Since schistosomiasis is not endemic in Rondônia, malaria is the major cause of splenomegaly in Costa Marques. The prevalence of splenomegaly and the frequency of big spleens was high in youngsters, but declined after the 11-14 year age group. The decline in splenomegaly in older people was probably unrelated to immunity to infection as parasite rates remained relatively constant in all age groups (Table III) or immunity to disease as the prevalence of asymptomatic parasitemia is very low (Prata et al., 1989). It is also unlikely that the decline in splenomegaly was caused by splenic fibrosis as both children and adults immigrated to Costa Marques at the same time and experienced similar numbers of malarial attacks.

The apparant failure of biannual applications of DDT to the interior of houses for malaria suppression is probably related to the exophilic behavior of the mosquito vectors. Recent studies on the biting behavior of local anophelines show that approximately 90% of them are collected outside houses with bimodal peaks in early evening and early morning hours (T. A. Klein, Núcleo de Medicina Tropical e Nutrição). DDT is known to alter the behavior of *Anopheles darlingi* in other areas, but its relationship with exophily, irritability and resting behavior in the Costa Marques area is unknown (D. R. Roberts, Uniformed Services University of the Health Sciences, Bethesda, MD).

Regarding control, it is instructive to compare the community at the Fort with the immigrant settlement in the forest along BR429 in terms of the quality of housing and availability of clinical services. The Fort is a stable community where the people have built and improved their homes over a number of years. Houses at the Fort are constructed of boards, and have shutters, screened windows, indoor plumbing and electricity. At night, the people usually cook, eat, bathe and watch TV in their "mosquito free quarters".

In contrast, the quality of immigrant housing varies with time in residence and agricultural success (Marques, 1987; Vesilind & Maze, 1987). During the first years of colonization, immigrants divide their time between the construction of temporary shelter, clearing the forest, planting subsistence crops, and home improvement. Initial shelters consist of tents made from plastic garbage bags or thatch suspended on poles without walls. Second stage shelters have thatched roofs with loosely constructed walls made of vertical poles. Third stage houses are relatively mosquito proof being constructed from boards with shingled roofs and window shutters. However, window screens are rare and the shutters and doors are often left open to reduce inside temperatures. During this entire developmental process, the pioneers are exposed to abundant mosquitoes.

The availability of medical care could also contribute to the difference in malaria endemicity at the Fort and along BR429. At the Fort a medical doctor and supporting staff provide a free service to 355 people who live within walking distance of the clinic. In contrast, the pioneers seek treatment at the clinic in the town which is usually a one day trip requiring expenditures for bus fares, food and lodging.

Techniques must be devised, tested and implemented to protect immigrants from malaria during the settlement process. The value of individual protection during the initial period of immigration through repellents, insecticide impregnated mosquito nets, and chemoprophylaxis is worthy of consideration. Habitat management through the identification and reduction of mosquito breeding sites must be emphasized as an essential part of farm development. Systems of financial support to accelerate the construction of mosquito proof houses must be implemented. Finally, the extension of the medical service from the town to the rural pioneers along BR429 is a top priority.

RESUMO

Conseqüência da imigração na prevalência da malária nas áreas rurais da bacia Amazônica no Brasil – Foram conduzidos estudos epidemiológicos de malária em três áreas rurais da Amazônia legal, no Estado de Rondônia: a cidade de Costa Marques, Forte Príncipe da Beira (Forte) e uma colônia de imigrantes perto da floresta. Esses estudos descrevem o papel da imigração na distribuição e prevalência da doença. Os registros hospitalares na cidade mostram que o número de casos de malária aumentou cinco vezes de 1983 a 1987 e o parasita predominante da malária mudou do *Plasmodium vivax* para o *P. falciparum*. O aumento da malária foi se-

guido pelo crescimento da imigração e colonização da floresta. Uma série de estudos epidemiológicos sugeriu que há ligação entre malária e imigração uma vez que a prevalência da malária foi de 1-2% para o Forte, uma comunidade estável, 8-9% em Costa Marques, uma comunidade em crescimento, e 14-26% na nova colônia de imigrantes na floresta.

Palavras-chave: malária – epidemiologia – Brasil

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