

## Malaria parasitological indices in the Cordillera Province (Santa Cruz Department, Bolivia)

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In 1988-1989, as part of a co-operative programme with the local Unidad Sanitaria, two cross-sectional surveys were carried out to study the prevalence of malaria in eight villages in the rural areas near Camiri, Boyuibe and Gutierrez (Cordillera Province, Santa Cruz Department, Bolivia). Thick and thin blood films were collected from all available two- to nine-year-old children at the end of the dry season, in the first survey (252 samples), and after the rainy season, in the second survey (346 samples). The parasite and gametocyte indices increased between surveys from 1.59-25.72 and from 0.40-1.73, respectively. All infections were due to *Plasmodium vivax*. Both prevalence and parasite load were lower in children aged two to four years than in older children. Prevalences, parasite loads, and parasite densities were highest in rural areas near Camiri and Gutierrez.

About 20% of all malaria cases recorded in the Americas originate from the Andean Sub-region of South America (Venezuela, Columbia, Ecuador, Peru and Bolivia), namely in areas where social and economic development has been rather slow and where no specific programme against malaria transmission has ever been undertaken. Increased use of antimalarial drugs in these areas, however, has probably had

a significant impact on mortality (Molineaux, 1988).

The Bolivian Highland, covering parts of the Departments of La Paz, Cochabamba, Oruro, Chuquisaca and Potosi, at altitudes of more than 3000 m, is free of malaria. In the Medio Plano, which is at altitudes of 1000-3000 m and includes the Department of Tarija and parts of the Departments of Cochabamba and

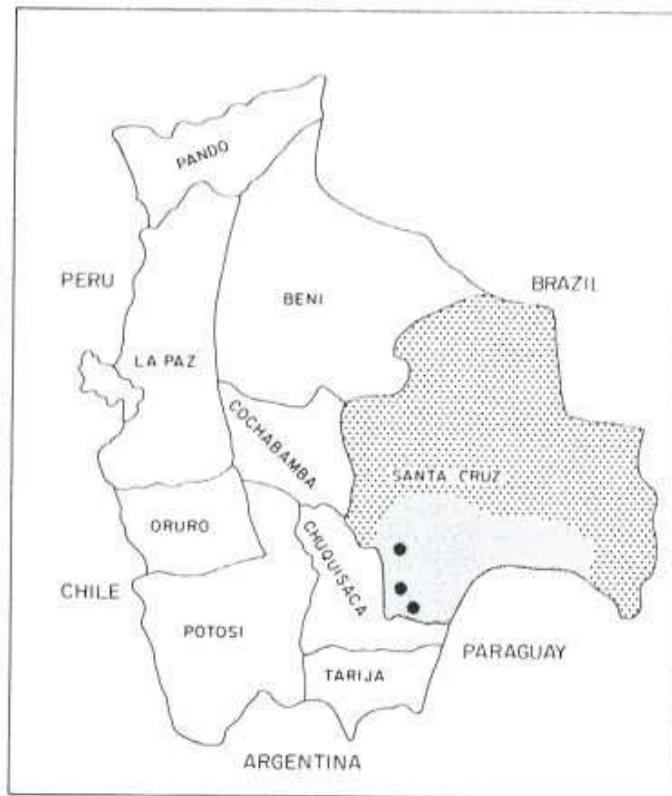


Fig. 1. Administrative boundaries of the Bolivian Departments and localization of the rural communities chosen for the study. (▨), Cordillera Province; (●), study area.

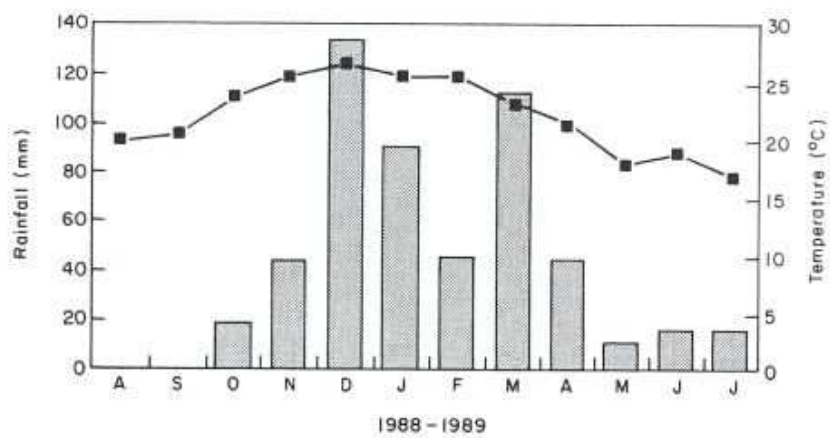


Fig. 2. Average monthly rainfall and temperatures recorded from October 1988 to July 1989 in Camiri.

Chuquisaca, transmission occurs from September to April. In the rest of the country, transmission may occur throughout the year. The administrative boundaries of the Bolivian departments are shown in Fig. 1.

Malaria in Bolivia is mainly due to *Plasmodium vivax*, but *P. falciparum* is also present (accounting for about 12% of all infections). The highest parasite incidence has been recorded in the Departments of Tarija (*P. vivax* only), followed by Pando (*P. vivax* and *P. falciparum*), Chuquisaca (*P. vivax* only), and Beni (*P. vivax* and *P. falciparum*) (Anon., 1991). As no data are available for the Department of Santa Cruz (hospital records merely indicate that malaria is present), malaria prevalence in Cordillera Province of this department was investigated in 1988–1989, as part of a co-operative programme with the local Unidad Sanitaria.

## SUBJECTS AND METHODS

### Study Area and Subjects

Cordillera Province (86 245 km<sup>2</sup> and 56 972 inhabitants registered in 1978) lies in south-eastern Bolivia, bordering the Rio Grande to the North, part of Chuquisaca Department to the South and West, and Paraguay to the East (Fig. 1). The temperature generally ranges from 17.7–26.3°C, but decreases to 5–10°C from May to September due to the 'surazo' winds from the Antarctic. The climate is described as sub-humid-dry (Sanabria, 1977). The monthly rainfall and average temperatures recorded from August 1988 to July 1989 by the meteorological station at Camiri airport are illustrated in Fig. 2.

The surveys were carried out in eight villages in rural areas near the towns of Camiri (Itanambicua), Boyuibe (Cumbaruti, Kamatindi, Ipitacuape) and Gutierrez (Pirirenda, Ipitacito, Tatarenda Nuevo, Tatarenda Viejo). The villages are located 5–40 km from the towns, at altitudes of about 900 m. Itanambicua is located in a windless valley, close to the Rio Parapeti. The four villages near Gutierrez are in an area rich in lakes, where the Rio Nanchahuazu and Rio Grande

meet. In contrast, Ipitacuape, Kamatindi and Cumbaruti are progressively further from the Rio Parapeti, the only river in the area.

Tall forest trees alternate with vegetation typical of savanna areas and with palms growing on clay soils (Unzueta, 1975). Armadillos (*Dasypus* spp.), opossums (*Didelphys* spp.), bats, rats and foxes are the common wild mammals, but monkeys are also present in the study area.

The populations of the villages (about 500 people each in Ipitacito and Itanambicua and 100–300 in each of the other villages) consist of mestizos descended from the Guarani and the Spanish colonizers. They live in poor dwellings, with walls of sticks, straw and clay and thatched roofs. A number of pools, besides lakes and rivers, supply water for domestic and agricultural purposes. The local economy is based on agriculture (mainly maize) and animal breeding (cattle, pigs, goats, chickens, etc.).

The health units of the Santa Cruz Department consist of a District Hospital in Camiri and nine Area Hospitals, including those of Gutierrez and Boyuibe, which organize village health workers in the rural areas.

### Methods

Two cross-sectional surveys were carried out: one in October–November 1988 (at the end of the dry season) and one in April 1989 (after the rainy season). A meeting with the inhabitants was organized to explain the purpose of the study and its procedure, and all the mothers were invited to participate. The children arrived at the established times and places, accompanied by their consenting mothers. Totals of 252 and 346 two- to nine-year-old children, corresponding to 20–30% of the resident population of each village, were examined in the first and second surveys, respectively.

Blood was collected from each child and thick and thin films were prepared and stained with Giemsa. Screening for malaria parasites was done on thick blood films by examination, with a × 100 objective under oil immersion, of at least 100 microscope fields each containing 10–20 leucocytes. *Plasmodium* species were identified on thin films, at the same magnification. The

children found infected with malaria were given chloroquine treatment.

The prevalence of malaria infection was estimated by determining the plasmodic index (PI), the parasite density index (PDI) and the positive parasite density index (PPDI). The corresponding gametocyte indices were also calculated. The PDI and PPDI were calculated following the methods adopted for the Garki Project (Molineaux and Grammicia, 1980). The PDI, defined as the proportion of all the microscope fields examined which were positive, is an estimate of the parasite load in the population. The PPDI, defined as the proportion of microscope fields found positive in smears from children found positive for *Plasmodium*, is an estimate of the density of infection in the population. The data were analysed statistically using the Chi-squared test and the *F*-test.

## RESULTS AND DISCUSSION

Examination of all 598 thick and thin films collected showed that all malarial infections were due to *P. vivax*. This finding is not surprising, considering the malariological data for the surrounding areas, such as the Chuquisaca Department and northern Argentina, in which *P. vivax* is the only species identified.

The parasite rate was 1.59% at the end of the dry season and 25.72% after the rainy season

(Table 1). Gametocyte indices were 0.40% and 1.73% in the two surveys, respectively. Plasmodic index and PDI were significantly lower in two- to four-year-old children than in the older children ( $P < 0.05$ ). The age-specific density distribution of *P. vivax* by season is given in Fig. 3.

Differences in prevalence and parasite density were observed among the three areas surveyed (Tables 2 and Fig. 4). The communities in the rural areas near Boyuibe showed lower prevalence, parasite load and density of infection than the rural areas near Camiri and Gutierrez ( $P < 0.001$ ). As shown in Fig. 5, the highest prevalences (45.6%, 34.9% and 34.3%) were found in Tatarenda Viejo, Tatarenda Nuevo (both in the Gutierrez area) and Itanambicua (Camiri area), respectively. These parasitological findings are consistent with malaria morbidity rates derived from the hospital records of Camiri, Boyuibe and Gutierrez (data not shown because they were incomplete).

Since the sanitary organization and facilities in the three areas are comparable, the variations in malaria prevalence and morbidity rates may be related to the microclimate, the spatial and temporal distribution of *Anopheles* larval breeding sites, and/or the feeding habits of adult *Anopheles*. The mosquitoes reported as malaria vectors in Bolivia are *An. darlingi* in the eastern plains and *An. pseudopunctipennis* in the Andean

TABLE 1  
*Parasitological indices by age and season in the Boyuibe, Camiri and Gutierrez areas*

Season	Years	No. of subjects examined	PI		PDI		PPDI	
			PV	GV	PV	GV	PV	GV
Dry	2-4	101	0	0	0	0	0	0
	5-9	151	2.65	0.66	0.11	0.01	4.15	1.06
	2-9	252	1.59	0.40	0.06	0	3.77	0
Rainy	2-4	131	21.37	0	0.68	0	3.18	0
	5-9	215	28.37	2.79	2.59	0.03	9.13	1
	2-9	346	25.72	1.73	1.87	0.02	7.27	1

PI, Plasmodic index; PDI, parasite density index; PPDI, positive parasite density index; PV, *Plasmodium vivax* index, any form; GV, *P. vivax* gametocyte index.

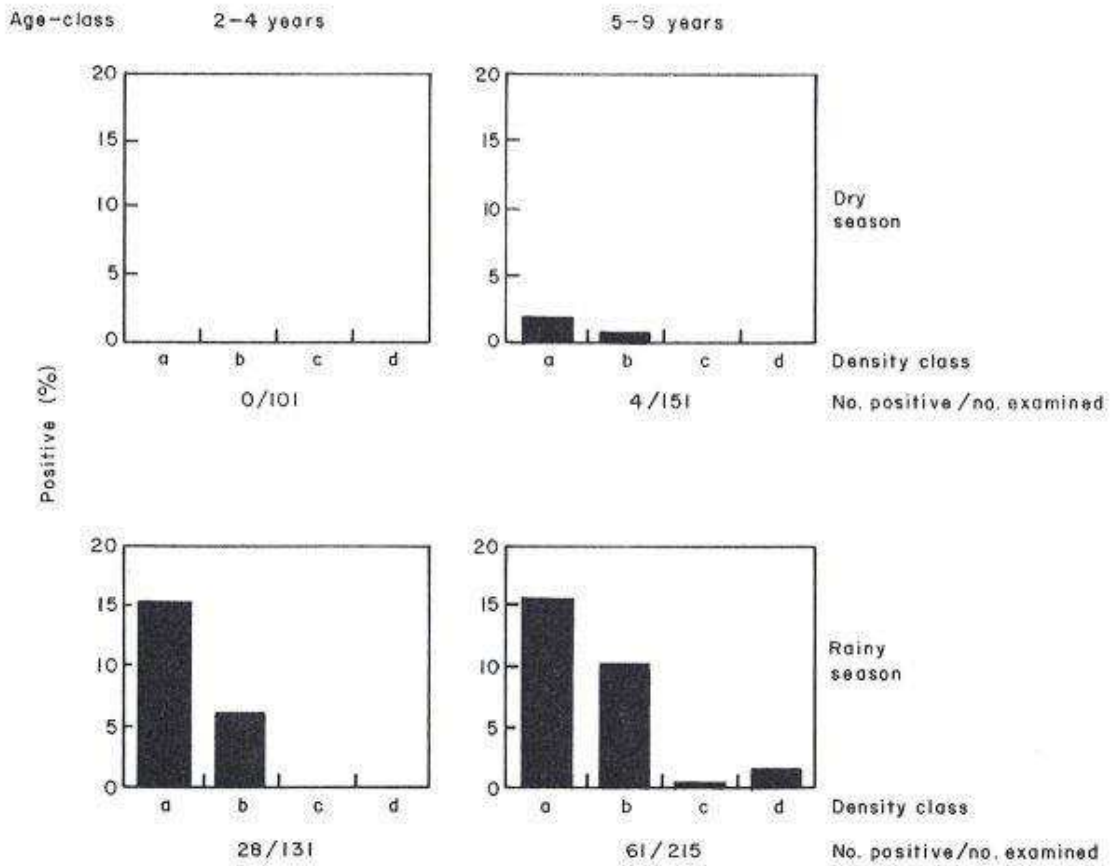


Fig. 3. Age-specific density distribution of *Plasmodium vivax*, by season. Each histogram shows the distribution of positives (as a percentage of the age-group) in four density classes defined by the proportion of positive thick film fields. The upper limits of the classes a, b, c, d are 0.04, 0.16, 0.64 and 1.0, respectively.

TABLE 2  
*Parasitological indices by season and geographical area*

Season	Area	No. of subjects examined	PI	PDI	PPDI
Dry	Boyuibe	80	1.25	0.02	2
	Camiri	71	2.82	5.63	2
	Gutierrez	101	0.99	9.90	10
	Total	252	1.59	0.06	3.77
Rainy	Boyuibe	71	7.04	0.18	2.56
	Camiri	99	34.34	2.38	6.93
	Gutierrez	176	28.41	2.26	7.95
	Total	346	25.72	1.87	7.27

PI, plasmodic index; PDI, parasite density index; PPDI, positive parasite density index.

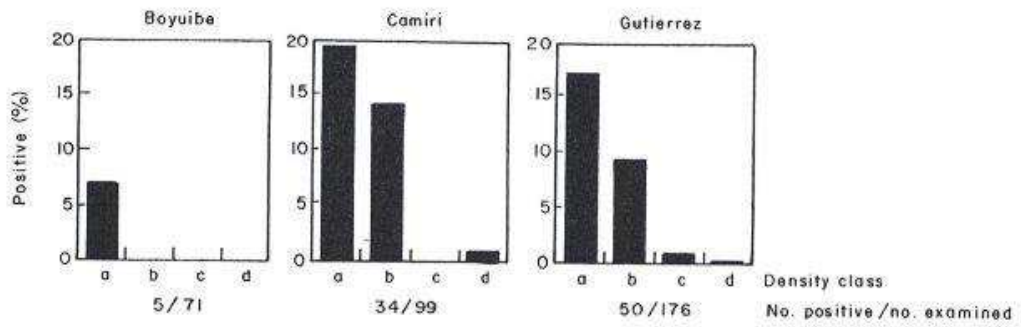


Fig. 4. Parasite density distribution by geographical area, of 89 infections with *Plasmodium vivax* observed after the rainy season. Each histogram represents the distribution of positives (as a percentage of the locality-group) into four density classes, defined as in Fig. 3.

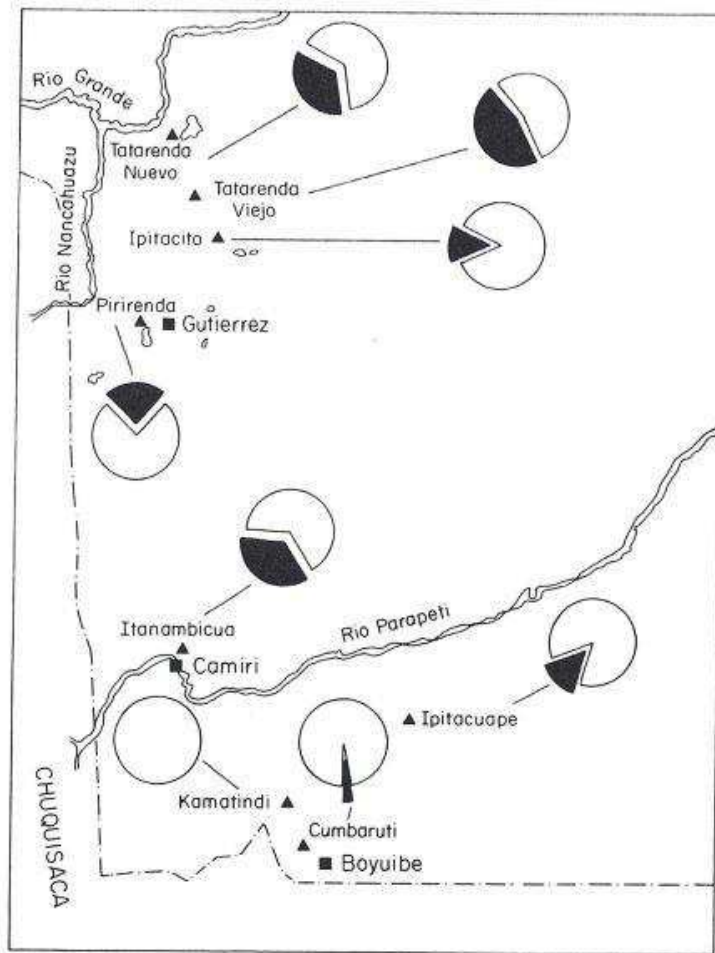


Fig. 5. Sketch map of the study area and prevalences observed after the rainy season.

foothills (Torres Goitia, 1966). The former breeds in shaded, still water (under swamp vegetation, grassy edges of rivers, pools, lagoons, rice fields, lakes and ponds), feeds mainly indoors, on man, and rests indoors after feeding. *Anopheles pseudopunctipennis*, which probably includes a complex of sibling species, prefers sunlit breeding places, especially habitats with algae (pools, puddles, seepages, edges of streams), bites man and domestic animals indiscriminately, indoors or outdoors, and rests outdoors after feeding (Bruce-Chwatt, 1986). The spatial distribution of one or both of these vector species in the study area may account for the various malaria prevalences observed, but no data are available.

The extension of these preliminary observations to other villages and to the vectorial system has already been planned, and should

allow us to obtain a more complete picture of malaria epidemiology in the Santa Cruz Department.

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