

Malaria Epidemiology in the Pakaanóva (Wari') Indians, Brazilian Amazon.

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Résumé : Epidémiologie du paludisme chez les Indiens Pakaanóva (Wari'), Amazone, Brésil.

Cet article présente les résultats d'une étude longitudinale sur l'incidence du paludisme (1998-2002) chez les Indiens Pakaanóva (Wari'), dans le sud-ouest de l'Amazonie brésilienne, d'après des données régulièrement recueillies dans les postes du réseau de la Fondation brésilienne de la santé, conjointement avec les services de santé des Indiens. Le paludisme est présent en permanence dans les zones habitées par les Indiens Pakaanóva. Au total, 1 933 cas de paludisme ont été diagnostiqués chez les Pakaanóva pendant cette période. Le ratio *P. vivax* / *P. falciparum* était de 3,4. Le *P. vivax* était responsable de 76,5 % des cas. Aucun cas d'infection par le *P. malariae* n'a été enregistré. Aucune variation par sexe n'a été vérifiée dans les taux d'incidence. La plupart des cas de paludisme ont été enregistrés chez des enfants de moins de 10 ans (45%). Environ un quart des cas a été diagnostiqués chez des femmes entre 10 et 40 ans.

Une étude entomologique menée dans deux villages Pakaanóva a donné un total de 3232 spécimens d'*Anopheles*, avec une prédominance d'*Anopheles darlingi* (94,4 %). La plupart de ces spécimens ont été capturés en plein air. Leur activité est plus intense à la tombée de la nuit et à l'aube. Il s'est avéré que les pratiques culturelles des Pakaanóva favorisent l'exposition des individus des deux sexes pendant les heures où l'activité des moustiques est plus intense (ex. La coutume de se rendre à la rivière à la levée du jour pour se baigner, puiser de l'eau, pêcher, chasser etc.).

Dans un environnement où les anophèles sont omniprésents et essentiellement exophiles, et dans lequel des hommes et des femmes de tous âges exercent des activités de plein air pendant les heures où l'activité des moustiques est plus intense, il est vraisemblable que le paludisme demeure endémique dans la région des Pakaanóva, exigeant ainsi le développement de stratégies alternatives respectueuses des aspects culturels et écologiques.

Summary :

This paper reports the results of a longitudinal study of malaria incidence (1998-2002) among the Pakaanóva (Wari') Indians, Brazilian southwest Amazon region, based on data routinely gathered by Brazilian National Health Foundation outposts network in conjunction with the Indian health service.

Malaria is present yearlong in the Pakaanóva. Statistically significant differences between seasons or months were not noticed. A total of 1933 cases of malaria were diagnosed in the Pakaanóva during this period. The *P. vivax* / *P. falciparum* ratio was 3.4. *P. vivax* accounted for 76.5% of the cases. Infections with *P. malariae* were not recorded. Incidence rates did not differ by sex. Most malaria cases were reported in children < 10 years old (45%). About one fourth of all cases were diagnosed on women 10-40 years old.

An entomological survey carried out at two Pakaanóva villages yielded a total of 3.232 specimens of anophelines. *Anopheles darlingi* predominated (94.4%). Most specimens were captured outdoors and peak activity hours were noted at early evening and just before sunrise. It was observed that Pakaanóva cultural practices may facilitate outdoor exposure of individuals of both sexes and all age groups during peak hours of mosquito activities (e.g., coming to the river early in the morning for bathing or to draw water, fishing, engaging in hunting camps, etc).

In a context in which anophelines are ubiquitous and predominantly exophilic, and humans of both sexes and all ages are prone to outdoor activities during peak mosquito activity hours, malaria is likely to remain endemic in the Pakaanóva, thus requiring the development of alternative control strategies that are culturally and ecologically sensitive.

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Anopheles
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Introduction

Malaria is a major cause of morbidity and mortality in the Brazilian Amazon, unequally affecting certain population groups such as gold prospectors, settlers, and Indians (4, 15, 21). With regards to indigenous peoples, both in the past as well as in the present, malaria has been the cause of serious epidemics, leading to high mortality and despair in affected villages (8, 12, 18, 19).

Malaria transmission in Amazonian indigenous populations is influenced by local environmental variables and by the composition of anopheline fauna, as well as by socio-demographic factors, including proximity and intensity of contact with frontier fronts. It is also influenced by predominant subsistence practices and human ecology, which may enhance individual exposure to vector biting activity. Despite this recognition, little research effort has been channeled to broaden the knowledge about the epidemiology of malaria in indigenous reservations situated in different areas of Amazonia (8).

This paper aims at analyzing the epidemiology of malaria in the Pakaanóva (or Wari) Indians of southwest Brazilian Amazonia. The study draws upon passive morbidity data made available by the public health service and field work aimed at describing the species composition and general behavior of the anopheline fauna at sampled villages.

Population and Methods

Study Area

The Pakaanóva population covered in this study currently totals some 2 288 individuals living in various villages located on five reservations in south-western Brazilian Amazonia, State of Rondônia (approximately 64-65°W, 11°S). The region is covered by floodplain and upland tropical rain forest and is crisscrossed by rivers of various sizes that flow east into the Mamoré River. Mean annual temperatures varies between 24-26°C, with annual rainfall of approximately 2,000 mm. Malaria is highly endemic in Rondônia; this State accounting for approximately 17% of malaria cases reported in Amazonia in 2001 (annual parasite index reported in the region inhabited by the Pakaanóva was 20.6 in 2001).

Pakaanóva houses are made of a raised platform of paxiuba palm (*Socratea exorrhiza*) boards covered with palm leaf mats. The walls are also made of irregular paxiuba boards that do not meet the fringes of the roof, thus allowing some space on all sides through which mosquitoes may easily enter the houses. Alternatively, houses may be built the same way, but starting directly from the ground level; in this case the floor is dirt. Pakaanóva economy is based on slash-and-burn horticulture; maize and cassava being their major staples. Hunting, fishing, and gathering of forest products are also important strategies in their subsistence, often motivating forest tracings that may last days or weeks and involves whole family groups.

Malaria Morbidity

Epidemiologic analysis was based on data gathered as part of the routine of the Brazilian National Health Foundation (FUNASA) outposts network in conjunction with the Indian health service. With the exception of Igarapé Ribeirão Reservation (for which data was not available), data from seven Pakaanóva outposts and reservations were gathered.

FUNASA's routine comprises of standard microscopic diagnosis of symptomatic persons based on Giemsa-stained thick blood smears and the provisioning of free treatment in accordance with Brazilian malaria control program recommendations (quinine for *falciparum* malaria and chloroquine/primaquine for *vivax*). Malaria cases notified between 1998 and 2002 among the Pakaanóva were analyzed in relation to the species of *Plasmodium* and patient's sex, age and place of residence. χ^2 tests were done in order to test for differences between age groups and sex. In order to verify correlation between season and morbidity, Pearson correlation was performed. All statistics were undertaken using SPSS for Windows (version 10.0).

Collection of Mosquitoes

Mosquito collections were made at three Pakaanóva villages chosen to represent a typical upland forest village (i.e., away from major rivers) and a typical riverine village (lying on the banks of a major river). Lage (located at the Igarapé Lage Reservation and presenting a population of approximately 190 individuals) was chosen as an example of the first situation. The village lies relatively close to the town of Guajará-Mirim and is located near a small artificial lake built by the Indian service in order to support a fish farm project that never took off. This small impoundment constitutes the major source of freshwater used by Lage villagers. Santo André and Bom Futuro villages were chosen to represent the second situation. These two villages are approximately 15 minutes away by boat and number approximately 320 persons. They are located on the left banks of the Pacaas Novos River, a tributary of the Mamoré River (due to their proximity and socio-environmental similarity, Santo André and Bom Futuro are analyzed as a unit and will be referred hereafter as Santo André only).

Collections of adult mosquitoes (Culicidae) were made during April (late rain season) and June (early dry season) 2002. Captures were conducted by one of the investigators (SA) and two agents of the malaria control service using aspirators (the malaria control agents carried out entomological surveys as part of their routine). Captures lasted six consecutive days at each village and were simultaneously carried out at the following sites at dusk (5:45-9:30 pm) and early morning (4:30-6:30 am): *intradomiciliary* (inside the Indian's houses), *peridomiciliary* (in the surrounding of the houses, approximately 1-2 meters distant from the external wall), and *extradomiciliary* (by the major water source used by the villagers for bathing and drawing water). Due to the inconvenience of entering the Indian's houses at early morning hours, *intradomiciliary* collections were carried out only at dusk 5:45-9:30 pm).

Ethics

Field work was conducted in accordance with recommendations issued by the Ethics Committee of the Escola Nacional de Saúde Pública and the National Committee for Research Ethics (CONEP). Malaria control program servicemen participating in fieldwork signed an informed consent form declaring their knowledge about possible risks involved in the collection of mosquitoes. Village leaders and indigenous health agents were previously informed about all activities to be carried out at their villages and agreed.

Results

Malaria Morbidity

A total of 1 933 cases of malaria were diagnosed in the Pakaanóva between 1998 and 2002 (504 cases in 1998, 322 in 1999, 533 in 2000, 336 in 2001, and 238 in 2002). The *P. vivax* / *P. falciparum* ratio was 3.4. *P. vivax* accounted for 76.5% of the cases. Mixed infections (*P. vivax* and *P. falciparum*) were detected in only 0.7% of the cases. Infections with *P. malariae* were not recorded. The total number of cases did not differ by sex ($p \geq 0.05$). Statistically significant differences ($p < 0.05$) were observed according to age group. Most malaria cases were reported in children < 10 years old (45%). About one fourth of all cases were diagnosed on women 10-40 years old (table I).

Tableau I.

Passive case detection of malaria in the Pakaanóva Indians, Brazilian Amazon, according to species of *Plasmodium*, age, and sex, from 1998 to 2002.

Détection des cas de paludisme chez les Indiens Pakaanóva, Amazonie brésilienne, en fonction des espèces de *Plasmodium*, de l'âge et du sexe, de 1998 à 2002.

age group (years)		<i>P. falciparum</i>		<i>P. vivax</i>		<i>P. falciparum</i> and <i>P. vivax</i>		subtotal		total
		male	female	male	female	male and female	male	female		
0-9	n	60	93	369	340	8	432	438	870	
	%	31.6	37.1	47.1	48.9	57.1	44.1	45.9	45.0	
10-19	n	69	87	261	235	3	331	324	655	
	%	36.3	34.7	33.3	33.8	21.4	33.8	34.0	33.9	
20-39	n	52	57	108	97	2	161	155	316	
	%	27.4	22.7	13.8	14.0	14.3	16.4	16.2	16.3	
≥40	n	9	14	45	23	1	55	37	92	
	%	4.7	5.6	5.7	3.3	7.1	5.6	3.9	4.8	
total		190	251	783	695	14	979	954	1933	

Considering all Pakaanóva reservations, the average malaria incidence between 1998 and 2002 was 188.3 inhabitants (table II).

Tableau II.

Incidence of malaria (per 1000 inhabitants) in seven reservations inhabited by Pakaanóva Indians, Brazilian Amazon, from 1998 to 2002.

Incidence du paludisme (pour 1000 habitants) dans sept villages habités par les Indiens Pakaanóva, Amazonie brésilienne, de 1998 à 2002.

year reservation	1998		1999		2000		2001		2002	
	pop.	cases /incidence								
Lage	317	158 498.4	353	127 359.8	393	176 447.8	316	62 196.2	369	55 149
Pacaas Novos	506	171 337.9	553	103 186.3	625	174 278.4	657	159 242.0	695	121 174
Deolinda	95	6 63.2	98	4 40.8	85	1 11.8	86	4 46.5	87	2 23.0
Sotério	269	43 159.9	301	11 36.5	301	5 16.6	300	7 23.3	324	2 6.2
Rio Negro Ocaia	395	99 250.6	414	71 171.5	472	153 324.2	483	98 202.9	489	48 98.2
São Luiz	50	25 500.0	57	4 70.2	64	14 218.8	60	3 50.0	65	8 123
Sagarana	234	2 8.5	246	2 8.1	225	10 44.4	211	3 14.2	259	2 7.7
total	1866	504	2022	322	2165	533	2113	336	2288	238

The distribution of cases was not homogeneous, with a strong concentration at Lage and Pacaas Novos, where about half of the population contracted malaria over the five years. A certain degree of fluctuation in incidence rates is noticeable between years - while data for the 1998-1999 and 2002 period suggests a drop in the number of cases of disease in most areas, an increase was reported for the years 2000-2001 at other reservations.

Malaria is present yearlong in the Pakaanóva, although the distribution of cases is not homogeneous throughout the year.

However, no statistically significant correlation was observed between month or season and incidence of malaria (Pearson's correlation coefficient, $r = -0.074$; $p = 0.62$) (figure 1).

Anopheline fauna

Altogether 3 800 mosquitoes (Culicidae) were collected (97.0% in the genus *Anopheles*). A total of 3 232 specimens of *Anopheles* were identified at the species level (318 from Lage and 2 914 from Santo André). The remaining (454) were damaged during transportation, precluding proper identification. The predominant species collected in both villages was *Anopheles darlingi* ROOT, 1926 (94.4%). Other species found (< 2%) included *An. albitarsis* LYNCH-ARRIBALZAGA, 1878, *An. argyritarsis* ROBINEAU-DESVOIDY, 1827, *An. benarrochi* GALBADON, COVA-GARCIA & LOPEZ, 1941, *An. braziliensis* (CHAGAS, 1907), *An. deaneorum* ROSA-FREITAS, 1989, *An.*

evansae (BRETHERS, 1926), *An. mattogrossensis* LUTZ & NEIVA, 1911, *An. mediopunctatus* (THEOBALD, 1903), *An. minor* (COSTA LIMA, 1929), *An. nuneztovari* (GABALDON, 1940), *An. oswaldoi* (PERYASSU, 1922), *An. shanoni* (DAVIS, 1931), *An. strodei* ROOT, 1926, and *An. triannulatus* (NEIVA & PINTO, 1922).

Most specimens were collected in the *extradomiciliary* (37.2% in Santo André and 38.7% in Lage) and in the *peridomiciliary* (50.9% in Santo André and 51.9% in Lage) environments. Peak mosquito activity (especially of *An. darlingi*) was observed at early evening and just before sunrise or early morning in the *peri* and *extradomiciliary* environments. Higher average capture rates of *An. darlingi* per hour of capture were observed at Santo André (averages 24.8, 44.3, and 64.0 at, respectively, *intradomiciliary*, *peridomiciliary*, and *extradomiciliary* environments). Lage averages were much lower for the same environments: 4.5, 11.0, and 7.5, respectively.

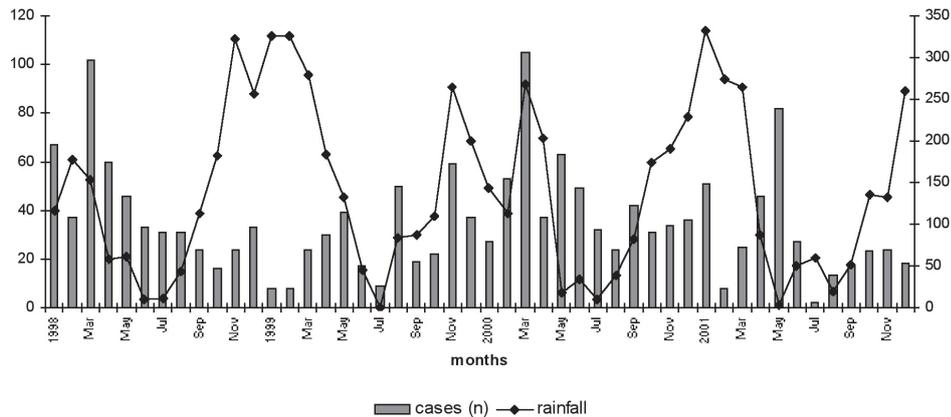
Discussion

Despite the recognition that passive morbidity data may be a source of bias in epidemiological analysis of population, this study shows that malaria is endemic in the Pakaanóva and its epidemiology is subject to the complex interaction between a number of environmental and social factors. There is no statistically significant correlation between incidence and season, what contrasts with the findings of other studies carried out with peasant and urban populations in other regions of Rondônia, which showed higher incidence rates of malaria in the dry season, i.e., June-August (2, 3).

Contrary to previous studies that have shown that malaria tends to be predominantly associated with male subsistence practices (e.g., lumbering, rubber tapping, fishing) (2, 5), malaria in the Pakaanóva does not seem to behave as a gender-related occupational hazard. Indigenous women in Amazonia, including Pakaanóva women, carry out important economic activities in the forest and gardens on an almost daily basis. On longer hunting trips that, among the Pakaanóva, usually take place during the rainy months and may last several days or weeks, women and children accompany the party and camp

Figure 1.

Rainfall and malaria cases in the Pakaanóva Indians, Brazilian Amazon, from 1998 to 2001.
Précipitations et cas de paludisme chez les Indiens Pakaanóva, Amazonie brésilienne, de 1998 à 2001.



out at temporary shelters that barely confer some protection against the rain, even less against anophelines. Once again, contrary to standard epidemiological reasoning, the finding that most malaria cases in the Pakaanóva were diagnosed in children < 10 years old does not necessarily indicate indoor transmission as it is commonly interpreted by most authors. As noted elsewhere, the daily cycle of indigenous women and children in Amazonia comprises uncountable outdoor activities associated with subsistence or leisure, many of which take place during peak anopheline activity hours (9).

Malaria presents a patchy distribution in Amazonia. Its epidemiology is dependent upon several not well-known local environmental and socio-demographic factors. Since few studies on the epidemiology of malaria in indigenous peoples in Amazonia have been carried out, data from studies conducted with rural or even urban non-indigenous populations tend to become the references for malaria epidemiology in the region. It is problematic to extrapolate epidemiological patterns observed among non-Indians, thus risking to generate a biased view of key epidemiological features in indigenous populations.

The relatively high percentage of infections caused by *P. falciparum* (22.8%) among the Pakaanóva should be highlighted, considering its potential to cause death. In the State of Rondônia, *P. falciparum* malaria caused approximately 80% of all malaria deaths recorded between 1980 and 1991 (6). It should also be noted that approximately 35% of all *P. falciparum* infections occurred in children < 10 years old. Younger age groups are particularly vulnerable to malaria and at higher risk of dying from the disease. Moreover, it should also be pointed out that nearly one fourth of all malaria cases reported in the period were diagnosed in women at peak reproductive years. Considering the very high fertility rates reported in Amazonian indigenous women (20), this observation constitutes a reason for concern since malaria during pregnancy adds an additional risk for expecting mothers (1, 7, 16).

Anopheles darlingi was the single most important malaria vector found at Pakaanóva reservations, exhibiting an almost exclusive exophilic behavior. Other potential vectors of malaria in the Pakaanóva, such as *An. deaneorum* and *An. oswaldoi*, also showed a marked degree of exophily. Despite limitations due to the short time span of mosquito collection, the entomological findings are in accordance with previous studies carried out in malaria endemic areas inhabited by rural or indigenous populations of Central Brazil and western Amazonia (3, 5, 9, 10, 11, 13, 14, 15, 17).

A typical day in the Pakaanóva starts by going to the village stream for bathing and fetching water early in the morning, often at a time when anophelines are still very active. The day also resumes by the water, when villagers bath and relax until sunset. Small children wearing little or no clothing accompany their parents in their daily tasks and are intensively exposed to anophelines. Despite Pakaanóva dwellings confer little protection

against anophelines, relatively few specimens were collected inside houses. Considering that mosquito habits may change in accordance with environmental factors and human interventions on the environment, in-house spraying carried out by the public health service is likely to yield limited results in hampering human-mosquito contact. In a context in which anophelines are ubiquitous and predominantly exophilic, and humans of both sexes and all age groups are prone to outdoor activities during peak mosquito activity hours, malaria is likely to remain endemic in the Pakaanóva, thus requiring the development of alternative strategies that are cultural and ecologic sensitive.

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