American Journal of Epidemiology and Infectious Disease, 2013, Vol. 1, No. 4, 27-33
Available online at http://pubs.sciepub.com/ajeid/1/4/1

DOI:10.12691/ajeid-1-4-1

Epidemiology of Malaria in three Geo-Ecological Zones along the Chad-Cameroon Pipeline

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Received August 06, 2013; Revised August 29, 2013; Accepted September 01, 2013

Abstract **Background:** Cameroon is endemic for malaria; however, the level of endemicity varies between the various eco-epidemiological zones. A public private partnership including many stakeholders was set up to control malaria along the Chad-Cameroon pipeline corridor. The present paper presents the baseline epidemiological data obtained in the zone prior to the implementation of control measures. **Methods:** A prospective study was conducted in three sites along the Chad-Cameroon pipeline including Bipindi in the forest humid zone, Meidougou in the high Guinean savanna and Dompta in the sudano-sahelian zone. A total of 2492 participants aged from 6 months to 10 years were included in the survey. Finger prick blood was taken to prepare thick and thin blood films for the determination of parasite density and identification of parasite species. **Results:** Malaria prevalence was 12.74% in dry season versus 55.5% in wet season in Bipindi; 2.77% against 3.6% in Meidougou and 26.8% versus 29.7% in Dompta. In wet season plasmodic index was 54.82% in Bipindi, 4.04% in Meidougou and 31.3% in Dompta site versus 13.40%; 4.09% and 28.8% during dry season. Only *Plasmodium falciparum* infections were detected. Splenic index in Bipindi was 52.79% in wet season versus 43.81% in dry season; 17.04% against 16.20% in Meidougou and 28.1% versus 25.8% in Dompta. Bipindi wasmeso-endemic for malaria in dry season and hyper-endemic in wet season. Meidougou was hypo-endemic and Dompta wasmeso-endemic in both seasons. **Conclusion:** This study along the Chad-Cameroon pipeline highlighted variations of the intensity of malaria transmission which is high and perennial in the forest humid zone, low and seasonal in the high savanna zone, moderate and perennial in the sudano-sahelian zone. These baseline results will help to evaluate the impact of control measures recommended by the Ministry of Health.

Keywords: *malaria, public-private partnership, transmission, prevalence, Cameroon*

Cite This Article: Eva Songue, Claudel Tagne, Pretty Mbouyap, Paul Essomba, and Roger Moyou –Somo, "Epidemiology of Malaria in three Geo-Ecological Zones along the Chad-Cameroon Pipeline." *American Journal of Epidemiology and Infectious Disease* 1, no. 4 (2013): 27-33. doi: ajeid-1-4-1.

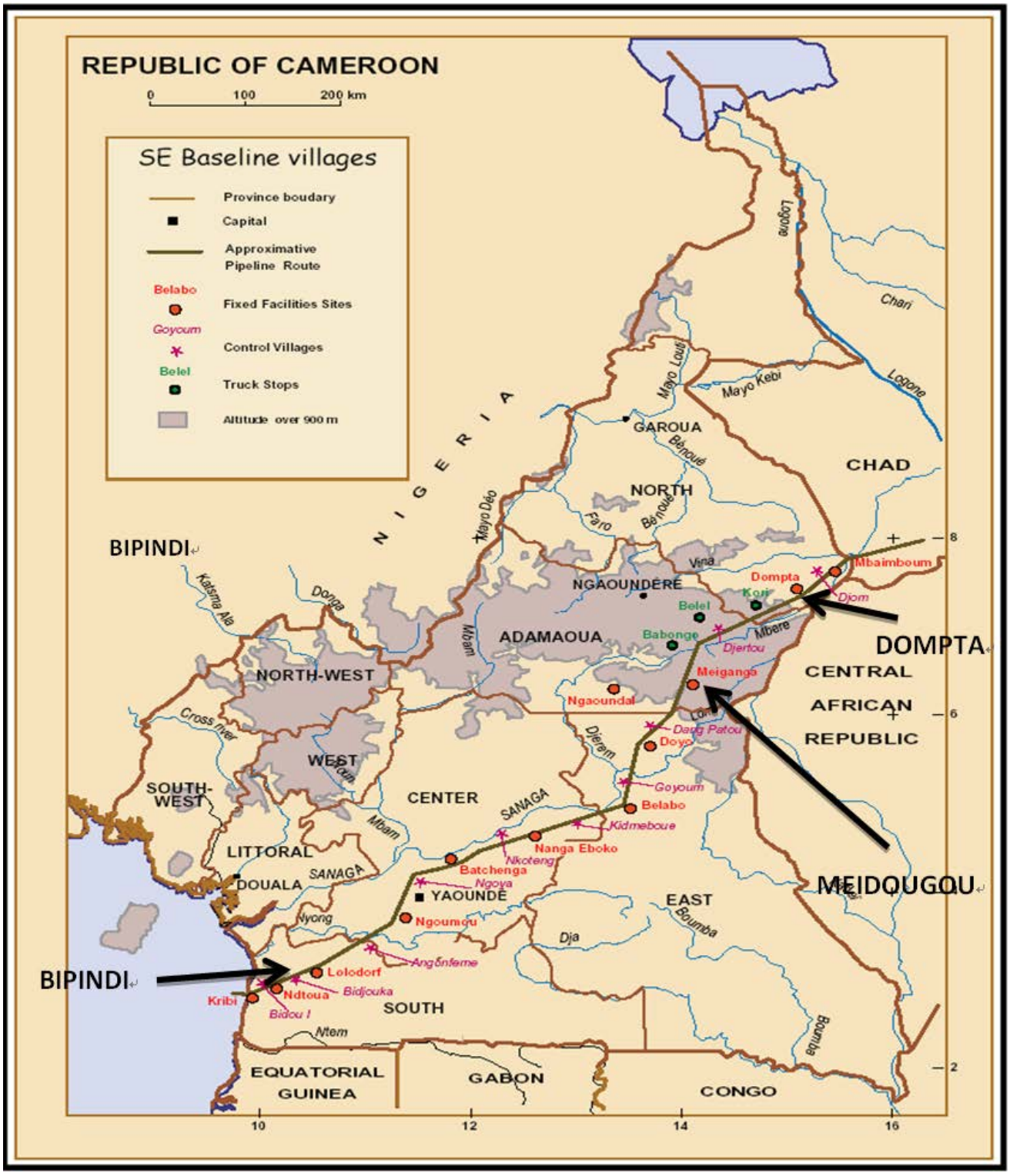
1. Introduction

Malaria remains a public health problem in Cameroon; the disease is responsible for 31% of consultations and 44% of hospitalizations in health facilities. It is responsible for 18% of deaths occurring in health facilities in the country. In children less than 5 years, 41% of deaths are due to malaria [1]. During the construction phase of the Chad-Cameroon pipeline, the Cameroon Oil Transportation Company (COTCO); the company that operates and maintains the pipeline in the country identified malaria as the first life threatening disease. Committed to the welfare of populations living along the pipeline corridor, COTCO initiated a partnership with the Ministry of Health and many other malaria stakeholders in 2010. The aim of this partnership was to put in place malaria control measures to reduce the impact of the disease in this zone. Large scale construction projects such as pipeline may be subject to environmental modification. In malaria endemic area this would greatly impact malaria transmission paradigm. Although in Cameroon malaria is endemic nationwide, the level of endemicity greatly varies from one eco-epidemiological zone to another [2]. Due to the absence of data on malaria transmission along the pipeline corridor, it was essential to collect baseline data to establish the epidemiology of malaria in this zone prior to the implementation of control measures .This paper presents results of baseline surveys carried out in 3 geo-ecological zones along the Chad-Cameroon pipeline corridor in which malaria indicators were determined.

2. Materials and Methods

2.1. Description of Study Site

This study was carried between 2010 and 2011 in Cameroonian villages located along the Chad-Cameroon pipeline corridor. Cameroon is found in Central Africa in the Gulf of Guinea. It is bordered by Nigeria to the West, Chad to the Northeast, the Central African Republic to the East, and Equatorial Guinea, Gabon, and the Republic of Congo to the South. The Chad-Cameroon pipeline has a length of 1054 kilometers and it is operated by ExxonMobil. It crosses Cameroon diagonally over a distance of 890 kilometers from South (Cameroon Atlantic border) to North (Chad border) (Figure 1). The pipeline goes across a great variety of physical environments: tropical evergreen forest, forest-savanna and savanna. The three selected sites were:



Legend: → Study site

Figure 1. Study sites along the Chad-Cameroon pipeline (Source: COTCO)

2.1.1. Bipindi Health Area (Humid Forest Zone)

Bipindi (10°25 E 3°05 N) is found in the South region which is in littoral evergreen forest. The climate is equatorial with two rainy and two dry seasons. An annual average temperature of 23-25°C is recorded and the annual rainfall ranges from 2000 to 10000 mm. The

malaria transmission is perennial and lasts 7 to 12 months. Villages included in the study were: Bidjouka, Bikalla and Bipindi. Villagers are principally hunters, farmers and fishermen. The main ethnic groups are the Ngoumba and the Bassa.

2.1.2. Meidougou Health Area (High Guinea Savanna Zone)

Meidougou (14°13'E 6°25'N)is located in the Adamawa region of Cameroon. It has a tropical climate and is characterized by two seasons. Rainfall varies between 1500 and 2000 mm annually and the average temperature is around 20°C. Malaria transmission is seasonal and lasts up to 7 months. Villages included in the study were: Bounou, Dankali and Meidougou. In this area, people are merchants, cattle rearers and farmers. The Gbaya and the Fulbé are the most prominent ethnic groups.

2.1.3. Dompta Health Area (Sudano-Sahelian Zone)

Dompta (15°09'E 7°18'N) is situated in the North Region. This zone is made up of the Mandara Mountains, the far north plains and the Benue valley. The annual rainfall ranges from 800 to 900 mm and the average temperature is 35°C. Rainy season lasts from June to October while the remaining seven months are dry. There is a dense hydrographic network made upof seasonal ("mayos") and permanent rivers. This zone is at risk of desertification. The malaria transmission is seasonal. Villages included in the study were: Mboko, Bougoui and Bemboyo. Villagers are mostly cattle rearers, farmers and belong to the Mboum and Bayaethnic groups.

2.2. Study Population

All children aged from six (6) months to ten (10) years living in the selected villages were eligible for the survey.

2.3. Study Design and Ethical Considerations

This study was conducted within the framework of a larger study to acquire baseline malaria data in order to evaluate the impact of malaria control measures and set up an effective and reproducible response involving multiple partners and the community. A cross-sectional, prospective and analytical study was carried out during high and low malaria transmission periods of each site. An ethical clearance was obtained from the Cameroon National Ethical Committee (Authorization N°040/CNE/SE/2010). Additional authorization was obtained from local traditional, sanitary and administrative authorities. Before collection of data, our chronogram was sent to the different village chiefs and community health workers concerned, for them to start sensitizing the population before our arrival. Parents or guardiansof children were informed that the participation of their children in the study was voluntary and that they could stop them from participating without any explanation at any time.

2.4. Clinical and Laboratory Procedures

Each child underwent a physical examination. Blood samples were collected using finger prick to prepare thick and thin blood smears for parasitological examination. Thin smears (only) were fixed with methanol. Thick and thin smears were stained with Giemsa solution and examined under a light microscope (Ivymen, Spain) by two independent microscopists following standard quality control procedures. A blood smear was considered negative if parasites were not detected after examining 100 oil-immersion fields of the thick smear. When malaria parasites were detected in a blood smear, the parasite density was determined on the base of the number of parasites per 200 leukocytes then multiplying by 40 to arrive at an approximate parasite count per microlitre of blood. This was based on the assumption that the average white blood cells count was 8,000/µl blood [2].Slide examination was done independently by two microscopists. When the difference in parasite density was more than 20 parasites/µl of blood, the slide was read by a third person and the mean of the two nearest values considered. Thin smears were examined to identify the *Plasmodium* species. Fever was defined as axillary T°C ≥ 37.5°C. Following national guidelines children with clinical or suspected malaria were treated with a standard dose of 4mg/kilogram body weight of Artesunate and 10mg/Kilogram body weight of Amodiaquine given once a day for 3 consecutive days.

2.5. Data Analysis

Data collected were doubly entered, validated using Epi data version 2.1 B and analyzed using statistical softwares: Stata (Stata Corporation, College Station, TX USA); CSPro3.3 and SPSS statistics 10.1 (IBM). Chi square statistics was used, the statistical significance was defined as $P<0.05$.

3. Results

3.1. Sociodemographic Data

A total of 2492 participantsaged 6 months to 10 years were recruited and included in the survey, 39.88% (n=994) was recruited during the rainy season and 60.11% (n=1498) during the dry season. The overall mean age of participants was 5 years ± 2.90 years and the sex ratio (M/F) was 0.97.

3.2. Malaria Prevalence

In Bipindi health area malaria prevalence was 12.7% (n= 33/259) versus 55.5% (n=131/236) respectively during the dry and the rainy seasons. In Meidougou, 2.7% (n=22/792) and 3.6% (n=16/445) of children had malaria parasites in their blood in dry and wet seasons. Finally in Dompta, a malaria prevalence of 26.8% (120/447) in the dry season and 29.7% (n=93/313) during the rainy season was obtained (Table I). Statistical difference was significant only in Bipindi (p=0.000).

3.3. Prevalence of Malaria by Gender

In the South, female had the highest malaria prevalence of 14.28% and 56.9% respectively in dry and rainy season. In Meidougou highest levels were recorded among boys (3.30%) in dry season and among girls (3.80%) in rainy season. In Dompta, highest malaria prevalence in dry season was registered among girls (28.44%) and among boys in rainy season (30.0%). No significant differences

were observed between males and females malaria prevalence (p>0.05).

3.4. Plasmodic and Splenic Indices

In high transmission period plasmodic indices were 54.82% in Bipindi, 4.04% in Meidougou and 31.3% in Dompta site versus 13.40%; 4.09% and 28.8% respectively during dry season. Highest plasmodic index was found in Bipindi in rainy season (54.82%) and in Dompta in dry season (28.8%). Splenic index recorded in Bipindi was 43.81% in dry season versus 52.79% in rainy season; 16.20% against 17.04% in Meidougou and 25.8% versus 28.1% in Dompta.Bipindi presented the highest splenic indices during dry and rainy seasons.A significant statistical difference was observed in Bipindi only (p=0.000) (Table 1).

3.4. Parasite Species

After examination of thin smears, only *Plasmodium falciparum* infections were detected in all thesites. No gametocyte was seen.

3.5. Parasite Density

During the dry season the highest parasitic load was observed in Meidougou (530 malaria parasite/µl of blood) and the lowest in Bipindi and Dompta (487 malaria parasite/µl of blood). In the high transmission period the parasitic load decreased from South (Bipindi) to North (Dompta), peaking at3095 parasite/µl in Bipindi, 1822 parasite/µl in Meidougou and1663 parasite/µl in Dompta. A significant difference on parasitic load according to seasons was observed in all sites (p=0.000).

3.6. Fever Prevalence

Overall fever prevalence (axillary temperature ≥ 37.5°C) among children was 18.41% (183/994) in rainy season and 1.85% (28/1498) in dry season (p=0.000). Fever prevalence per site was 24.15% (57/236) in rainy season versus 2.70% (7/259) in dry season in Bipindi; 13.93% (62/445) against 1% (8/792) in Meidougou and 20.44% (64/313) versus 2.90% (13/447) in Dompta.

3.6. Relationship between Malaria Parasites and Fever

The overall prevalence of fever associated with *P.falciparum* infections was 3.66% during the low transmission period and 24.79% in high transmission period (p=0.000). Per site, percentage of fever associated with *P.falciparum* infections was lower during dry season than rainy season: 3.03% (dry season) against 28.24% (rainy season) in Bipindi; 5.17% (dry season) versus 28.57% (rainy season) in Meidougou and 3.29% (dry season) against 19.35% (rainy season) in Dompta. The differences between dry and rainy season were statistically significant (p=0.000).

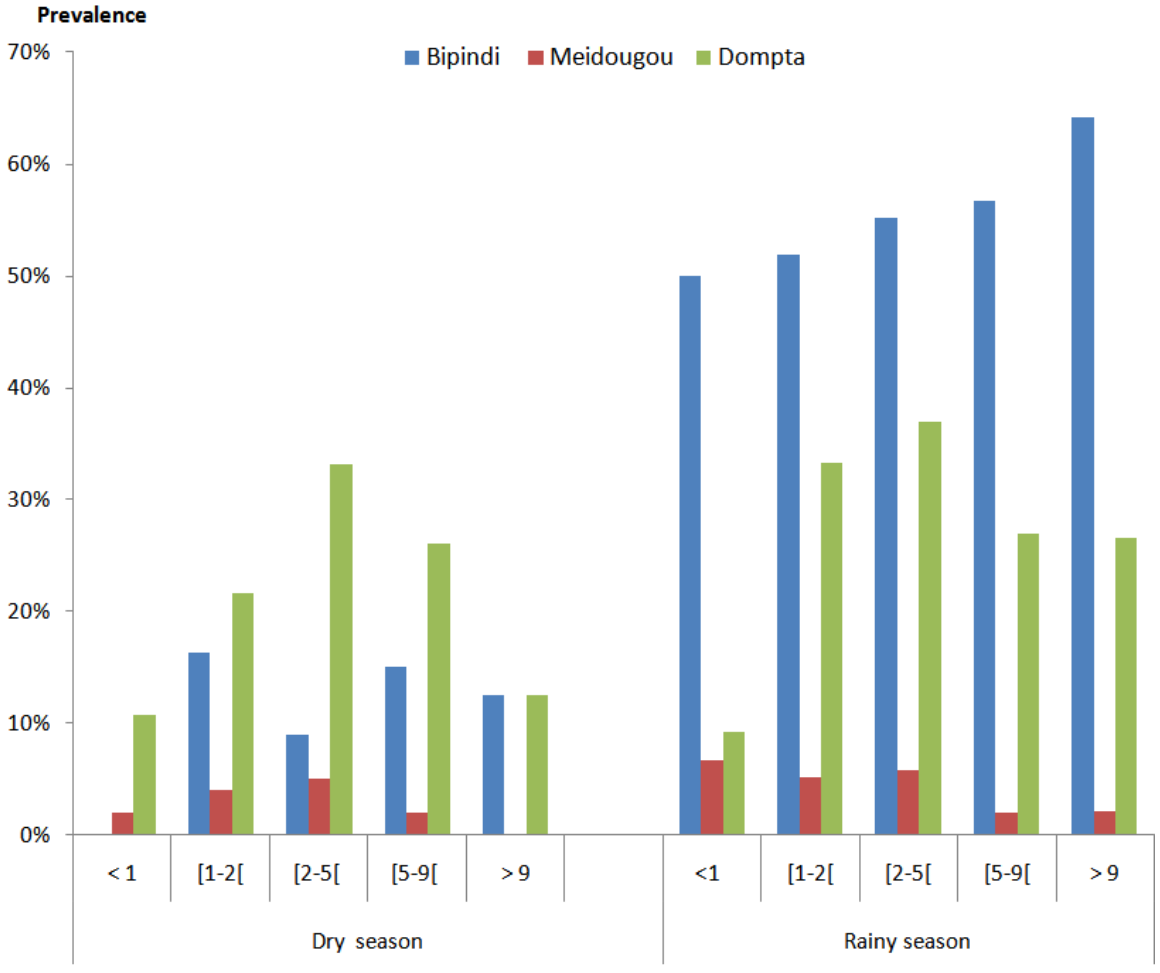


Figure 2. Malaria prevalence in study area according to age group

4. Discussion

Monitoring malaria endemicity requires good quality data that can measure and define disease burden across ecological and geographical environments encountered in Cameroon. This study was performed to estimate baseline malaria parameters in children from 6 months to 10 years old along the Chad-Cameroon pipeline corridor prior to the implementation of malaria control measures. The study showed variations in malaria indicators according to seasons and regions. In the three study sites only *Plasmodium falciparum* infections were observed and the gametocyte index was 0 in dry and rainy seasons.

4.1. Malaria Prevalence

In the forest zone where malaria transmission has been reported perennial, a low prevalence was recorded in dry season while in wet season more than half of blood smears obtained from participating children were positive for malaria. Parasitaemia was highest in children over 9 years in the rainy season and in the 1-2 years age group during dry season. A relationship between age and parasitaemia was only found in wet season, it increases with the age of children. Among children aged less than 5 years, a prevalence of 53.09% was recorded in the wet season, a similar prevalence was also found in children under 5 years by Bigoga et *al.* [4] in the Southwest region of Cameroon while Nzeyimana et *al.* *[5]* in Ivorian forest area reported a prevalence of 87% in subjects from 0 to 14 years. Although the prevalence decreases in dry season, malaria transmission occurs throughout the year and does not stopbecause *An.gambiae* or *An.nili*, species which transmit malaria in wet season are relayed by *An.moucheti* during the dry season [6]. These findings are in line with the result from Mouchet et *al* which showed a perennial malaria transmission in the equatorial region [7]. In the high Guinean savanna in both dry and wet seasons, the prevalence was low (2.77% and 3.60% respectively).In children less than five years, the prevalence rate was 4.33% and the highest prevalence was recorded in this age group in both seasons. Low prevalence has also been reported in Mali during the dry and rainy seasons [8]. In the North region (Dompta) 26.8% and 29.7% of blood smears were positive for malaria parasites in dry and wet season respectively. Similarly in Bipindithe highest prevalence was found in children agedless than fiveyears (28.50% in the dry season; 32.48% in the wet season). A similar prevalence rate was found by Asante et *al.* [9] in the wet semi-equatorial forest area in Ghana. Although prevalence rate had increased from dry to wet season in the three study sites, significant difference was observed only in Bipindi as shown by Table 1. Many factors influence the prevalence of malaria parasite. It increases with the level of exposure or with the level of resistance of malaria parasites to antimalarial drugs and decreases with increasing immunity and the use of effective antimalarials. The parasite prevalence and level of exposure are closely related [10]. The highest levels of malaria prevalence were recorded in the Northern part of the country during dry season (Dompta) and in Bipindi (rainy season). Studies on knowledge, attitudes and practices of communities of these three sites showed a bed net use rate of 37.86% in Bipindi; 54.4% in Meidougou and 75.2% in Dompta. Nevertheless therapeutic itinerary taken by the villagers in case of malaria was inadequate in Bipindi and Dompta. The majority of respondents from these sites use antimalarial drugs from street vendors contrary to Meidougou where 60% of respondents went to health facilities [11,12]. Anthropogenic changes such as significant migration of populations, changes in the vegetation and the development of transport infrastructure in the three study sites since the construction of the pipeline have contributed in changing the epidemiology of malaria in various environments encountered.

Table 1. Malaria parrameters according to transmission period and study sites

		Bipindi	Meidougou	Dompta
Number of children included	*Dry season*	259	792	447
	Rainy season	236	445	313
Prevalence (%)	*Dry season*	12.7	2.7	26.8
	Rainy season	55.5	3.6	29.7
	P-value	0.000	0.576	0.386
Parasite density (parasite/µl blood)	*Dry season*	487	530	487
	Rainy season	3095	1822	1663
	P-value	0.000	0.000	0.000
Plasmodic index (%)	*Dry season*	13,40	4.09	28.8
	Rainy season	54,82	4.04	31.3
	P-value	0.000	0.872	0.573
Splenic index (%)	*Dry season*	43.81	16.20	25.8
	Rainy season	52.79	17.04	28.1
	P-value	0.01	0.247	0.592

4.2. Parasite Density

The seasonal variation in parasite density was marked. In dry season the mean parasite count did not exceed 600 malaria parasite/µl of blood in all the sites. In the wetseason a decrease in parasite density from south to north was observed, the maximum density was recorded in the forest area (Bipindi) and the lowest in theSudano-sahelian area (Dompta). These parasite densities are higher than those recorded in Ivory Coast [5]. Other authors have reported results close to those of Meidougou and Dompta during the rainy season [9,13,17]. Nevertheless, prevalencefound in the three study areas are lower than results found in other studies in Cameroon [4,18].

4.3. Splenicand Plasmodic Index

Malaria is usually accompanied by an increase of the size of the spleen. In areas where malaria is the leading cause of splenomegaly, it is an indicator for assessing the importance of malaria. Although in our study sites, splenomegaly has been reported as a major sign of malaria infection, soil-transmitted helminthes (STH) related diseases can also cause splenomegaly. Authors [14,15] in Cameroon found a prevalence rate of STH above 25%. Another factor such as malnutrition can also cause the enlargement of the spleen. From South to North according to the Yaoundé classification [10], Bipindi is meso-endemic for malaria in the dry season and hyper-endemic in the wet season. Meidougou is hypo-endemic in both dry and wet seasons and Dompta ismeso-endemic in both seasons.

4.4. Fever Prevalence and Malaria Parasites Associated with Fever

The prevalence of fever was 1.85% and 18.11% in dry and wet season (p=0.000). Associated with malaria parasite; prevalence of fever was 3.66% in dry season against 24.79% in rainy season (p = 0.000). Lower prevalence of fever was found in Mozambique [18], in which the prevalence of fever was 9.4% and 5.7% associated with malaria. In Molykothe prevalence of fever associated with malaria was 75.8% in 2000 and 72.4% in 2004 [17].

4.5. Regional Variations

Along the Chad-Cameroon pipeline corridor, the prevalence of malaria showed variations according to regions. Malaria is hyper-endemic in the South region (Bipindi), hypo-endemic in North (Meidougou) and meso-endemic in Dompta. Similarly, the mean parasite density showed regional variations decreasing in the rainy season from low lands (Bipindi) to highlands (Meidougou and Dompta).

5. Conclusions

Results from this study highlighted variations of the intensity of malaria which is high and perennial in the rain forest zone, low and seasonal in the high savanna zone, moderate and perennial in the sudano-sahelian zone. In the three sites, malaria is caused by *Plasmodium falciparum*. Lack of data in the study area before the pipeline construction cannot allow us to confirm the direct role of environmental modifications due to the pipeline construction in the sustainability of malaria in the zone. Nevertheless these baseline results will helpus to evaluate the impact of control measures recommended by the Ministry of public health (such as long lasting impregnated bed nets or artemisinin based combined therapy) on malaria endemicity in the zone.

Acknowledgements

This study was financed by Exxon Mobil Foundation. The authors are grateful to COTCO, the communities for their participation in the survey, Mrs Amédée Motsebom and Ngué Monique for microscopic examination, and Sidénou Téma Francklin for data analysis. We are also grateful to all the project partners for their contribution and collaboration.

Authors Contribution

ES, PE and RMS planned the study design. PM,CT,ES and RMS performed field activities. ES and RMS drafted the manuscript. All authors read and approved the final manuscript.

Statement of Competing Interests

The authors declare no competing interests.

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