

## Context

Irrigation schemes have been developed in the Senegal River valley, a natural border between Mauritania and Senegal, with the principal aim to support and improve rice production. Rice fields are known to be a favourable habitat for *Anopheles gambiae sensu lato* (s.l) larvae, the major malaria vector in sub-Saharan Africa. In Mauritania, the construction of dams along the Senegal River resulted in an increase in irrigated land areas, mainly for rice (*Oryza sativa* L.) cultivation, and changes in the epidemiology and transmission of water-related, vector-borne diseases, such as malaria, schistosomiasis, and filariasis.

For instance, prior to the construction of the Diama dam located about 22 km upstream from the Atlantic Ocean in 1986, epidemiological data from the Senegalese side of the Senegal River showed that malaria was the most frequently encountered water-related disease in the medical records of the majority of districts along the river. However, studies conducted in the same zone several years later showed an extremely low seasonal malaria transmission despite the establishment of primary and secondary vectors of malaria, *An. arabiensis*, *An. gambiae sensu stricto* (s.s.), and *An. pharoensis*.

In general, *An. arabiensis* is both anthropophilic and zoophilic, and *An. gambiae s.s* is more anthropophilic than zoophilic. On the right bank (i.e., the Mauritanian side) of the Senegal River, malaria surveillance has not been performed regularly along the river valley. The objective of this study was to update epidemiological data on malaria in Rosso, one of the major Mauritanian cities situated along the Senegal River where a permanent irrigation scheme has been established for decades.

## Materials and Methods

### A. Study Area

The study was carried out in Rosso (latitude 16°34'0" N; longitude 15°48'0" W), one of the major cities of Mauritania and the regional capital of Trarza, situated on the Senegal River, a natural frontier between Mauritania and Senegal (Figure 1). Rosso is the main gateway for passengers between Senegal and Mauritania. According to the latest available national census data in 2013.

### B. Study population and malaria diagnosis

The present longitudinal study was conducted in the health centre of Rosso from February 2015 to December 2016. Patients of all ages with fever (defined as a measured axillary temperature  $\geq 37.5$  °C) or history of fever during the previous 48 h before consultation. Presenting spontaneously to the health centre, were included in the study. After obtaining informed consent from the patient, finger-prick capillary blood samples were obtained for haemoglobin measurement and malaria diagnosis. Two drops of capillary blood samples were spotted on Whatman 3MM filter paper, dried, and stored for molecular analysis.

The presence of malaria parasites was detected on-site by rapid diagnostic test (RDT) and microscopic examination of Giemsa stained thick and thin blood films, and later confirmed by PCR at the University of Nouakchott.

### C. Data Analysis

The proportion of ownership of bed nets was calculated as the number of individuals with at least one bed net in the household over the total number of recruited participants. Proportions were compared using Fisher's exact test. The Spearman's rank correlation coefficient was computed to compare the relationship between the number of ITNs ownership by household and their frequency of use.

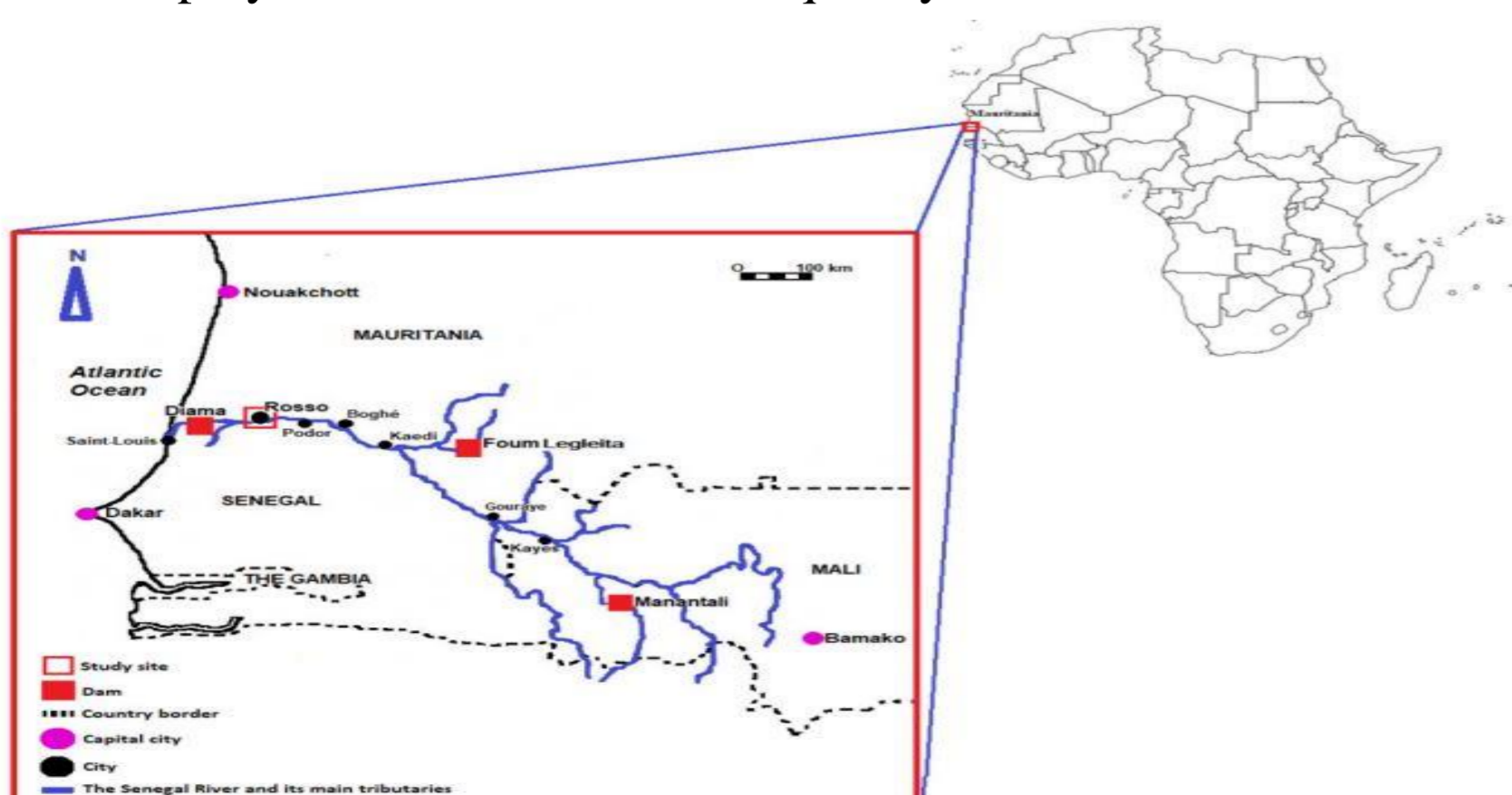


Figure 1: Map of southern Mauritania showing the geographical location of Rosso.

## Results

A total of 322 specimens were analysed by MALDI-TOF MS profiling. The febrile patients (n = 318) were screened for malaria using a rapid diagnostic test (RDT) for malaria and microscopic examination of blood smears. Diagnosis was later confirmed by polymerase chain reaction (PCR). The mean age of 318 febrile patients was 25.1 (range 1–80 years). Only 7 (2.2%) and 2 (0.6%) had a positive RDT and thick smear, respectively. PCR confirmed the diagnosis in two *Plasmodium vivax*-infected patients. Most participants (198/318, 62.3%) had no recent travel history outside Rosso. The majority of the febrile patients (90%, 284/311) owned at least one insecticide-treated net (ITN). The frequency of the use of ITNs was not significantly associated with season (rainy vs. dry seasons; p = 0.9) or with the number of ITNs per household (rs = 0.07; n = 285; p = 0.19). Of 285 individuals with ITNs, only two (0.7%) with no travel history were PCR-positive for malaria (Tableau 1 et 2, Figure 2).

Tableau 1 : Baseline characteristics of the study population.

Characteristics	2015	2016	2015–2016
Number (%)	246 (77.4)	72 (22.6)	318 (100)
Sex (n, %)			
Male	119 (48.4)	34 (47.2)	153 (48.1)
Female	127 (51.6)	38 (52.8)	165 (51.9)
Age group (year; n, %)			
<5	23 (9.3)	7 (9.7)	30 (9.4)
5–9	35 (14.2)	15 (20.8)	50 (15.7)
10–19	42 (17.1)	14 (19.4)	56 (17.6)
20–39	95 (38.6)	20 (27.7)	115 (36.2)
40–59	38 (15.4)	9 (12.5)	47 (14.8)
≥60	13 (5.3)	7 (9.7)	20 (6.3)
Mean axillary temperature (°C) (range)	37.9 (35.3–40.5)	38.0 (36.0–40.0)	38.0 (35.3–40.5)
Mean haemoglobin (g/dL) (range)	10.1 (6.0–13.0)	11.0 (8.4–12.0)	10.5 (6.0–13.0)
Ethnicity			
Moors	179 (72.8)	48 (66.7)	227 (71.4)
Black Africans	67 (27.2)	24 (33.3)	91 (28.6)
Travel history			
Yes	106 (43.0)	14 (19.5)	120 (37.7)
No	140 (57.0)	58 (80.5)	198 (62.3)
Malaria test positivity			
Rapid diagnostic test	4 (2 Pf + 2 Pan)	3 (Pv)	7 (2.2)
Microscopy	1 (Pf)	1 (Pv)	2 (0.6)
Polymerase chain reaction	1 (Pv)	1 (Pv)	2 (0.6)

n: number; Pf: *Plasmodium falciparum*; Pv: *Plasmodium vivax*; Pan: any other *Plasmodium* species.

Tableau 2 : Ownership of insecticide-treated nets among febrile patients in Rosso.

Characteristics	2015	2016	2015–2016
Household ownership of ITNs (n, %) <sup>1</sup>			
Yes	223 (91.1)	62 (93.9)	285 (91.6)
No	22 (8.9)	4 (6.1)	26 (8.4)
Number of ITNs per household (n, %)			
1	42 (18.8)	8 (12.9)	50 (17.5)
2–4	130 (58.3)	41 (66.1)	171 (60.0)
>4	51 (22.8)	13 (20.9)	64 (22.4)

<sup>1</sup>There were 7 missing data. Insecticide treated nets: ITN.

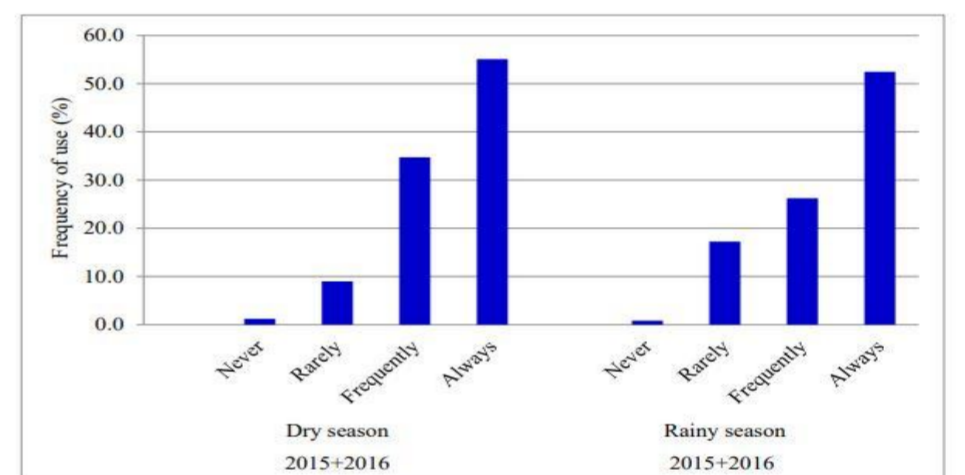


Figure 2: Seasonality and frequency of use of insecticide-treated nets among febrile patients recruited at the health centre of Rosso.

## Discussion

Our results corroborate previous entomological and parasitological studies from both the left and right banks of the Senegal River where low malaria transmission had been observed in many Senegalese villages as well as in Mauritanian cities.

Similar findings were also reported from the villages near the city of Niono in Mali, where irrigation water is drawn from the Niger River. In that Malian study, it was observed that in the irrigated zone, malaria transmission remained low throughout the year despite high densities of mosquitoes characterised by low anthropophily, while in the nonirrigated zone, malaria transmission was close to zero during the dry season and high just after the rainy season despite lower mosquito densities.

The only previously published survey of malaria epidemiology in Rosso, conducted in 2004–2006, reported comparable malaria prevalence between adult febrile patients (2.5%) consulting at the regional hospital of Rosso and asymptomatic school children aged 6–14 years (0.9%) living in two villages near Rosso, suggesting low exposure to infective mosquito bites of the population living in this area.

The malaria situation in Rosso, as well as that in several cities and villages along the Senegal River, seems to be under control and, with more aggressive interventions, be amenable to malaria elimination along the river valley. In this context, novel point-of-care malaria diagnostic technologies under development may play a role in the near future.

## Conclusion

Although dams favour the creation of new breeding sites for *Anopheles* mosquitoes, malaria transmission in Rosso remains very low, most likely due to the frequent use of bed nets by the majority of the local populations and zoophilic preference of *An. arabiensis*.

Further epidemiological studies, including entomological surveys, are required in the Sahelian zone of the country, both inland and along the Senegal River, where *P. falciparum* is known to be the predominant *Plasmodium* species, to understand the current malaria situation and implement appropriate malaria control strategies.