Grant agreement no. 243964

QWeCI

Quantifying Weather and Climate Impacts on Health in Developing Countries

Deliverable D5.3.b: Entomological profile of the Barkedji Environment and Health Observatory for malaria and RVF vectors

Start date of project: 1st February 2010 Duration: 42 months

Lead contractor: IPD
Coordinator of deliverable: IPD
Evolution of deliverable

Due date :	M29
Date of first draft :	M30
Start of review :	13 April 2013
Deliverable accepted :	29 April 2013

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Grant agreement no. 243964
QWeCI
Quantifying Weather and Climate Impacts on Health in Developing Countries

Deliverable D5.3.b: Entomological profile of the Barkedji Environment and Health Observatory for malaria and RVF vectors

Start date of project: 1st February 2010 Duration: 42 months

Lead contractor: IPD
Coordinator of milestone:
Evolution of milestone

Due date : M
Date of first draft :
Start of review :
Deliverable accepted

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Study area and methodological approach

The entomological investigations were conducted in the area of Barkedji situated in the Sahelian biogeographic domain from July 2010 to December 2011. This area is located in the north central part of Senegal (West Africa). Its climate is characterised by a long dry season of approximately 8-9 months. Its is situated between isohyets 200 and 400 mm with a hydrographic network of temporary ground pools filled with water at the onset of the rainy season remaining as the unique source of water during the dry season. The dominant ethnic group is Peuhl mainly cattle and sheep farmers.

Many entomological studies were conducted in this area mainly in Barkedji village. These studies were mainly focused on vectors of arboviruses such as Rift Valley and West Nile fever and malaria vectors. *An. gambiae* and *An. arabiensis* are the main malaria vectors in the area. These two species are usually present only during the rainy season. Malaria transmission is seasonal and concentrated on four months of the year, from September to December and occur both indoors and outdoor human dwellings.

For RVF virus, the Barkedji area is considered as an enzootic area of the virus as its amplification was observed in the area. Mosquito species were identified in the area include *Ae. vexans*, *Cx. poicilipes*, *Ae. ochraceus*, *Ae. fowleri*, *Ma. africana* and *Ma. uniformis*.

The global approach of the entomological field studies was to estimate the entomological parameters described in the Liverpool Malaria Model (LMM) as well as new parameters relevant for i) a validation for malaria in Senegal and ii) a development of models for Rift Valley Fever (RVF). Thus, efforts were focused on analysing the (LMM) and related literature. Based on the LMM generic and key parameters a protocol for the entomological field collections was designed for malaria as well as RFV vectors. This protocol was shared and discussed with members of the Senegalese platform for validation. For malaria vectors, 6 villages belonging to 4 different land cover/land use (wooded savanna, shrubby savanna, steppe and bared soils) were selected. A protocol was set up for mosquito sampling twice a month from July (beginning of the rainy season) to December in order to study the spatio-temporal variations of entomological parameters described in LMM. For RVF vectors, the main ground pools were selected: Niakha, Kangaledji, Fourdou and Ngao for the first year. During the second year the Beli Boda gound pool was incorpored in the study because an automatic climatic station was set up near this ground pool by the CSE.

Malaria vectors collections were made bi-monthly from July to December during each year. In villages, mosquitoes were collected using two sampling methods: (1) capture of females landing on human (HLC) from 08:00 pm to 06:00 am indoor and outdoor and (2) pyrethrum spray catches (PSC) of resting females. For RVF vectors, two main collection methods were chosen to study the vectors attractiveness to human and small ruminants as well as their abundance around ground pools. Collections were made using CDC light traps near ground pools and bed net traps using human, goat or sheep as baits.

Upon collections, mosquitoes were sorted and identified morphologically. Blood meals from fed mosquitoes were blotted onto filter paper to determine the host source in the laboratory. A random sample of malaria vectors from each species were dissected to extract ovaries and to determine the mosquito reproductive age. Mosquitoes were stored individually in numbered vials with dessicant for laboratory processing (malaria vectors) whereas for RVF vectors, they were pooled in monospecific pools for virus isolation in the laboratory.

Findings

Malaria vectors

Mosquito collections

Overall, during the two years surveys, 2061 anopheline specimens belonging to 7 morphological species were collected by HLC. *An. gambiae* was the predominant species whatever the village considered (Table 1). *An. pharoensis* was collected in the six villages but was abundant only in Kangalédji village. The other anopheline species were collected at very low frequencies.

The resting collections in human dwellings have permitted the collection of 2798 anopheline females (Table I). Only *An. funestus*, *An. gambiae* and *An. pharoensis* were collected by this method. The other anopheline species were absent. As for HLC, *An. gambiae* was the predominant species collected followed by *An. pharoensis* that was absent in Kangaledji village. *An. funestus* was also very rare and collected only in Barkedji village. The molecular identification of species of the *An. gambiae* in a random sample (306 specimens) showed the presence of *An. gambiae* M form and An. arabiensis with the predominance of the latter species.

Table I: Number of anopheline collected in the six villages selected

Species	Barkédji		Kangalédji		Keur Bandji		Niakha		WSK		WS	
	HLC	PSC	HLC	PSC	HLC	PSC	HLC	PSC	HLC	PSC	HLC	PSC
An. coustani	0	0	1	0	0	0	0	-	1	0	0	-
An. flavicosta	0	0	1	0	0	0	0	-	0	0	0	-
An. funestus	0	1	0	0	1	0	0	-	0	0	0	-
An. gambiae	1214	2247	294	46	29	249	339	-	67	252	70	-
An. pharoensis	14	1	11	0	3	1	2	-	3	1	3	-
An. rufipes	1	0	0	0	0	0	0	-	0	0	0	-
An. ziemanni	0	0	4	0	0	0	0	-	2	0	1	-
Total	1229	2249	311	46	33	250	341	-	73	253	74	-

HLC : Human-Landing Collections, PSC : Pyrethrum Spray Collections
WSK=Wouro Samba Kibel, WS=Wouro Sileymani

Biting cycles

The mean number of bite per person per night (bpn) were significantly different for *An. gambiae* between the six villages ($F_{5,60}$=3.8, p=0.004). The mean densities ranged from 0.3±3.9 bpn in Keur Bandji village to 3.4±2.5 in Barkedji (Figure 1). Between the two years surveys, significant differences were observed only in Barkédji village (p=0.006).

The study of the temporal variations in *An. gambiae* populations dynamics showed that for each of the six villages, the HBR was higher in 2010 compared to 2011 (Figure 2). In addition, depending to the village or the study year, the biting peak was variable. In Barkedji village, the peak of aggressiveness was observed in October both in 2010 and 2011. In Wouro Samba Kibel and Wouro Sileymani villages, the peak was in September in 2010 whereas in 2011, the biting activity was very low. In Niakha, the peak was very early in 2010 and very late in 2011 whereas in Kangaledji and Keur Bandji, the peaks were observed respectively in October and September.

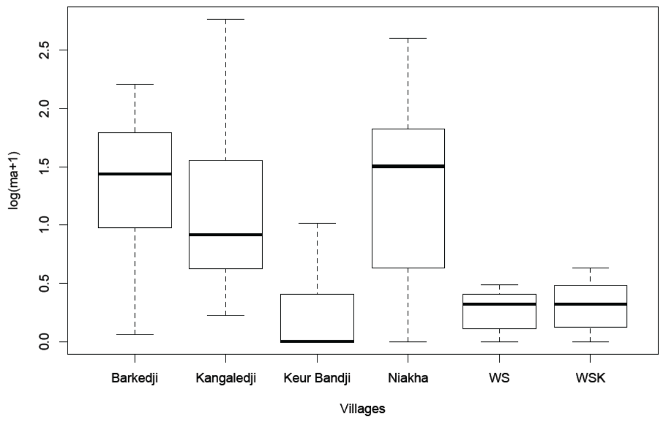


Figure 1 : Spatial variations of the Human Biting Rate for the species of the *An. gambiae* complex in the 6 villages selected

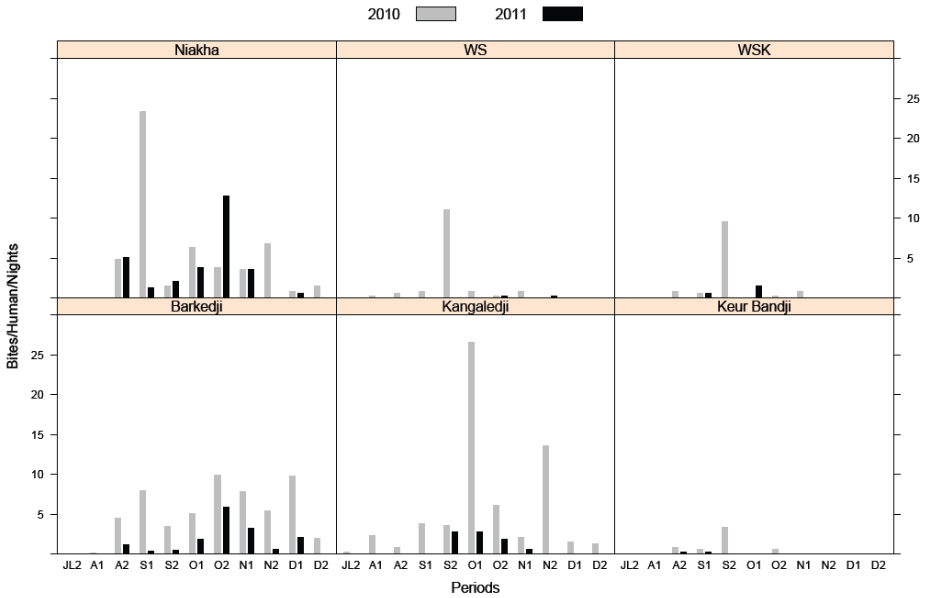


Figure 2: Temporal variations of the Human Biting rate for the species of the *An. gambiae* complexin each of the villages selected

Host-seeking behaviour

Overall, in the six villages, *An. gambiae* females showed exophagic tendency. The percentage of mosquitoes collected outdoors ranged from 52.5% in Barkedji village to 76.2% in Kangaledji village (Figure 3).

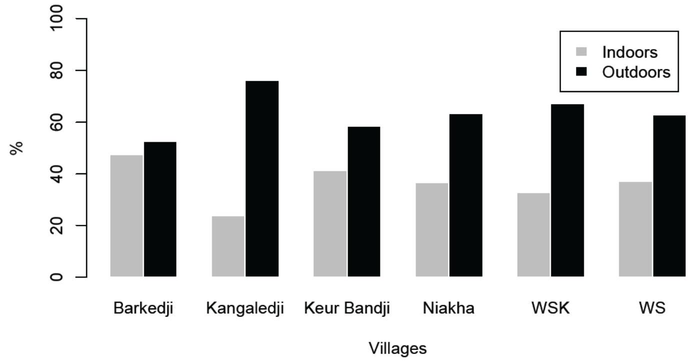


Figure 3: Variations of the endophagous and exophagous rates between the 6 villages

A total of 1013 blood meals from indoor resting females collected by PSC were tested using ELISA technique. Mixed blood meals were observed in the three villages and represented respectively 18.5%, 34.7% and 10.7% in Barkedji, Keur Bandji and Wouro Samba Kibel.

The proportion of human blood meals was 43.2±32.7% in Barkedji, 27.6±26.7% in Keur Bandji and 35.5±38.2% in Wouro Samba Kibel (not significantly different (p=0.74). Blood meals from cattle were taken on Bovine, ovine, Chicken and Horse (Figure 4).

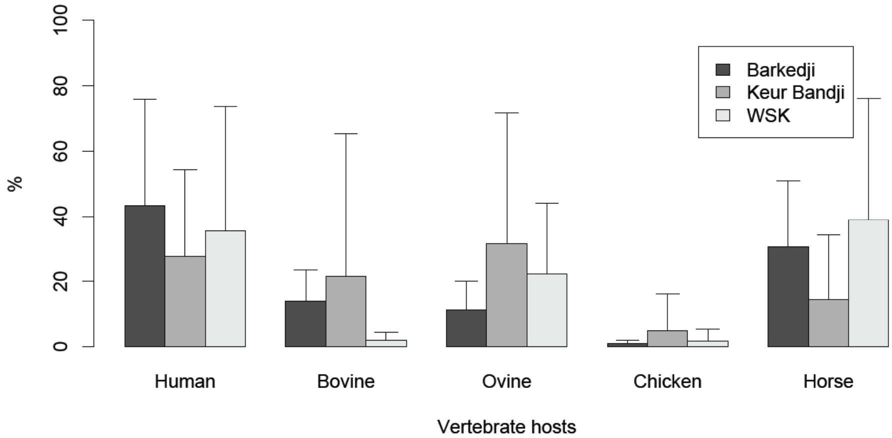


Figure 4: Variations of the frequencies of the different blood meals
Taken in each vertebrate host in the villages selected

Parity rate

Samples 1133 females collected in the six villages were dissected for parity determinations (Table II). The parity rates were not significantly different for *An. gambiae* between the six villages (χ^2=10.9, df=5, p=0.05).

Table II: Mean parity rates of *A. gambiae* females collected in the villages selected

Villages	Dissected	Parous	PR (%)
Barkedji	751	311	41.4 [37.9-44.9]
Kangaledji	157	63	40.1 [32.8-47.9]
Keur Bandji	18	11	61.1 [38.6-79.7]
Niakha	169	83	49.1[41.7-56.6]
Wouro Samba Kibel	18	6	33.3[16.3-56.2]
Wouro Sileymani	20	13	65 [43.3-81.9]

PR: parity rate

Circumsporozoite and entomological inoculation rates

In total, 1757 *An. gambiae* females collected in the six villages were processed by ELISA for *P. falciparum* circumsporozoite antigen detection. All specimens giving positive ELISA results were retested. In total, 8,3% [CI 95%=7.11-9.69] of *An. gambiae* were positive for *P. falciparum* circumsporozoite antigen. The mean infection rates were 7.55% [CI 95%=6.11-9.3], 8.18% [CI 95%=5.46-12.07], 15.38% [CI 95%=6.15-33.53], 9.93% [CI 95%=6.96-13.98], 12.5% [CI 95%=6.19-23.63] and 3.33% [CI 95%=3.33-16.77] respectively for Barkedji, Kangaledji, Keur Bandji, Niakha, Wouro Samba Kibel and Wouro Sileymani.
The study of the entomological inoculation rate showed that transmission was very heterogeneous and was very low in Wouro Samba Kibel, Wouro Sileymani and Keur Bandji

in 2010 and 2011 and was concentrated between September and November. It was higher in 2010 than in 2011 (Figure 5). In the three others villages, malaria transmission was perceptible both in 2010 and 2011 and was higher in 2010. It ranged from 55 infective bites (IB) in Bakedji to 78 IB in Kangaledji in 2010 and from 15 IB in Kangaledji to 66 IB in Niakha.

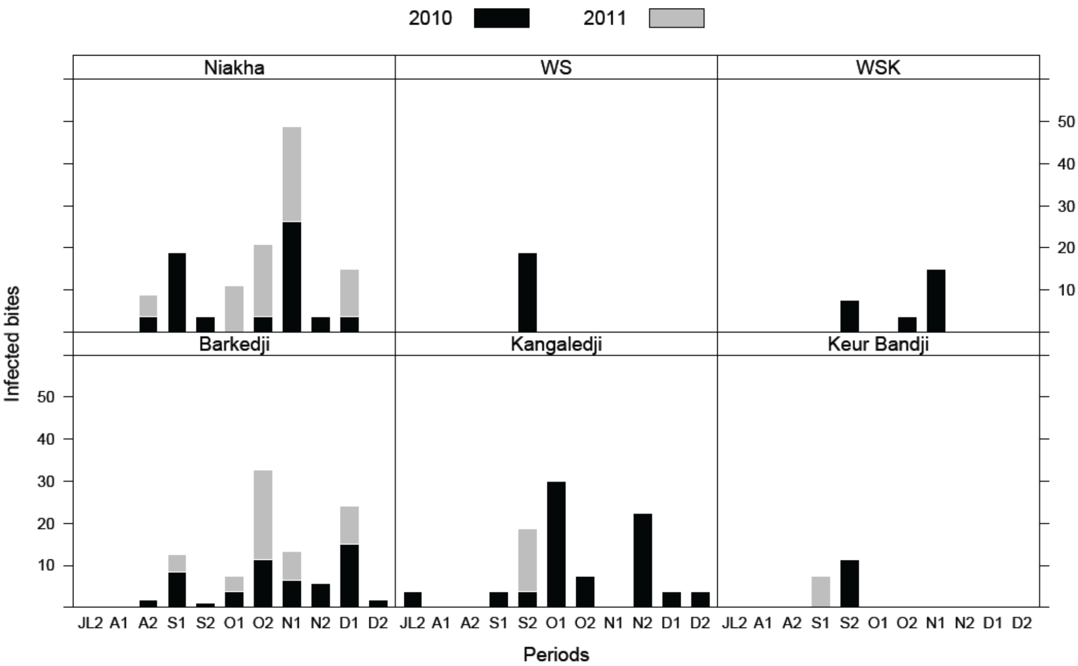


Figure 5: Variations of the entomological inoculation rates in the villages selected

RVF vectors

Mosquito collections

In total, 28716 mosquitoes belonging to 35 species and 6 genera were collected. *Aedes vexans* and *Culex poicilipes* represented respectively 23 and 27% in 2010 and 34.4% and 49.6% in 2011.

Around the main ground pools in the area, the mean numbers of mosquitoes of these two species were higher in 2011 in comparison to 2011 (Figure 6). However, no significant difference was observed between the two years. The study of the general trends in mosquitos' densities around the ground pools showed that the lowest densities were observed in 2010 both for *Cx. poicilipes* and *Ae. vexans*. Except for *Cx. poicilipes* in 2011, the densities were higher in 2011 for each ground pool. However whatever the ground pool considered and the species, no significant difference was observed between the densities in 2010 and 2011.

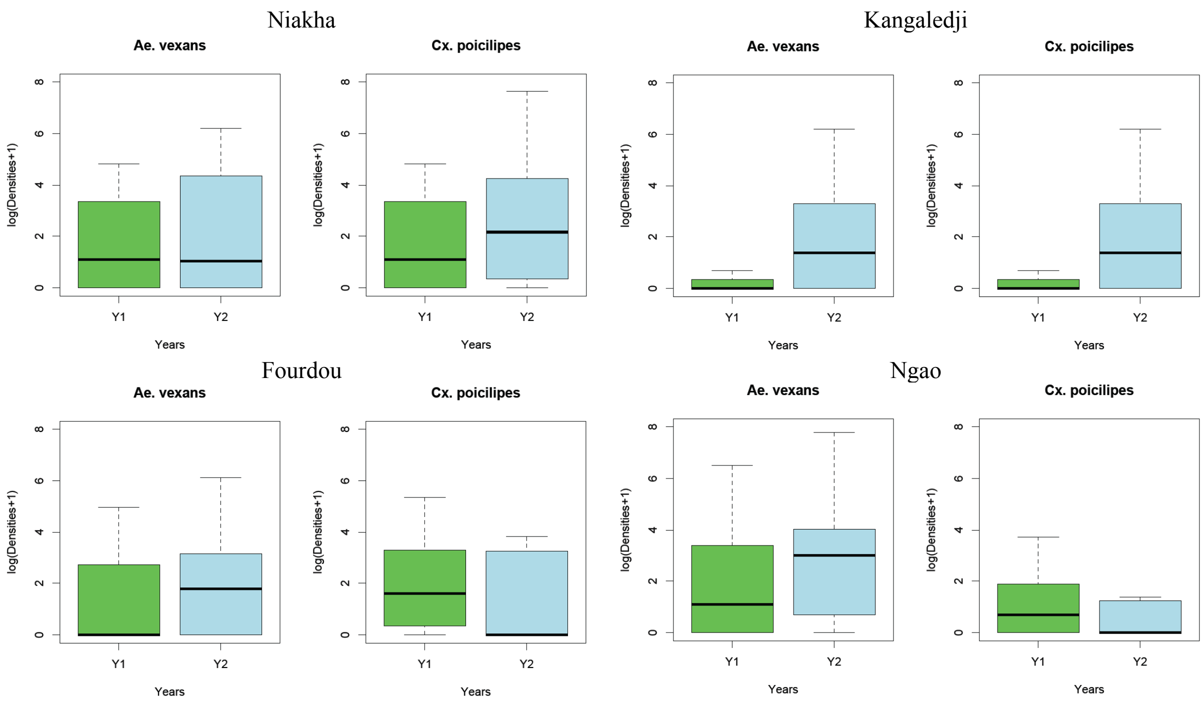


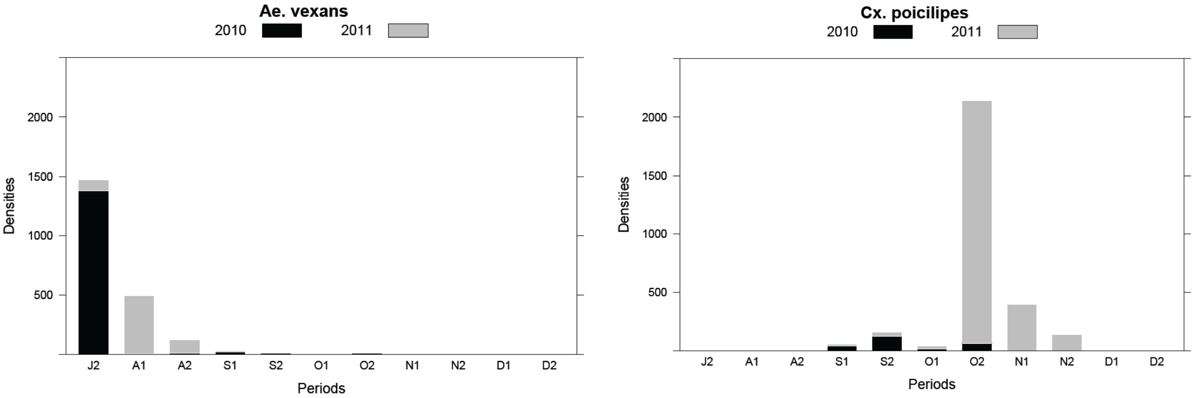
Figure 6: Spatial variations of *Ae. vexans* and *Cx. poicilipes* densities in the four ground pools studied

Populations dynamics

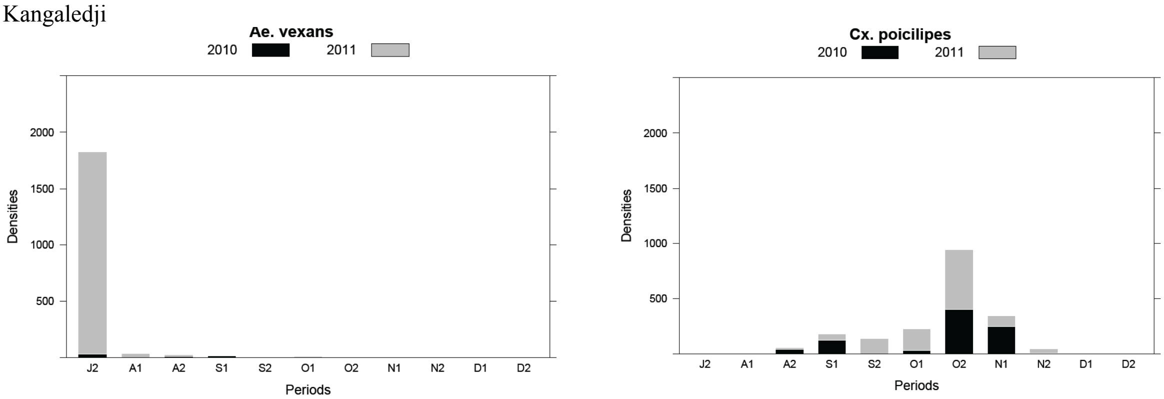
The study of the temporal variations of *Ae. vexans* and *Cx. poicilipes* densities showed that the populations dynamics of these two mosquito species depend on rainfall. Indeed, for *Ae. vexans*, whatever the ground pool considered, the peak densities are observed at the beginning of the rainy season in July. *Ae. vexans* densities decreased then and no specimen was observed after September excepted in Ngao ground pool where *Ae. vexans* specimens were collected up to October both in 2010 and 2011. Between these two years, the densities of *Ae. vexans* were generally higher in 2011.

For *Cx. poicilipes*, the maximum densities were observed from the middle to the end of the rainy season. In fact, *Cx. poicilipes* densities increased regularly with the onset of the rainy season to reach peak activities at the end of October. In Ngao ground pool, where the lowest densities were observed, the peak was earlier and was observed in September.

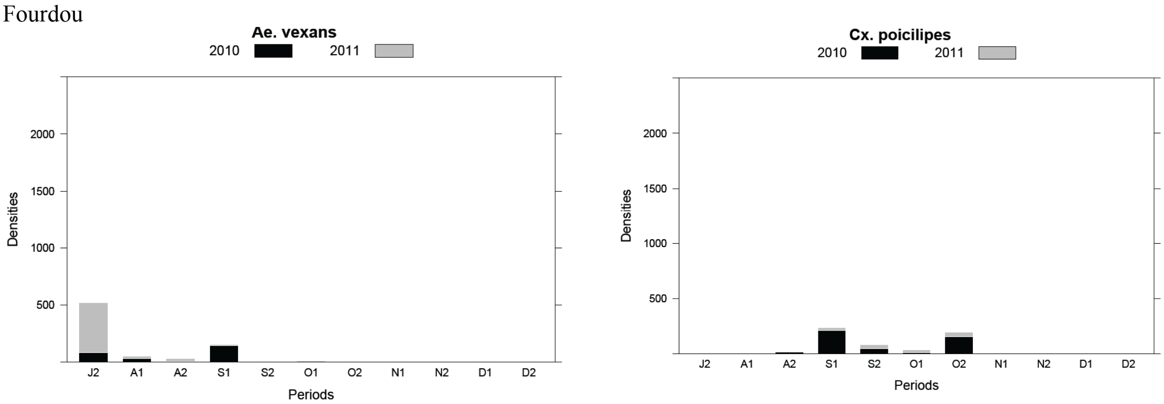
Niakha



Kangaledji



Fourdou



Ngao

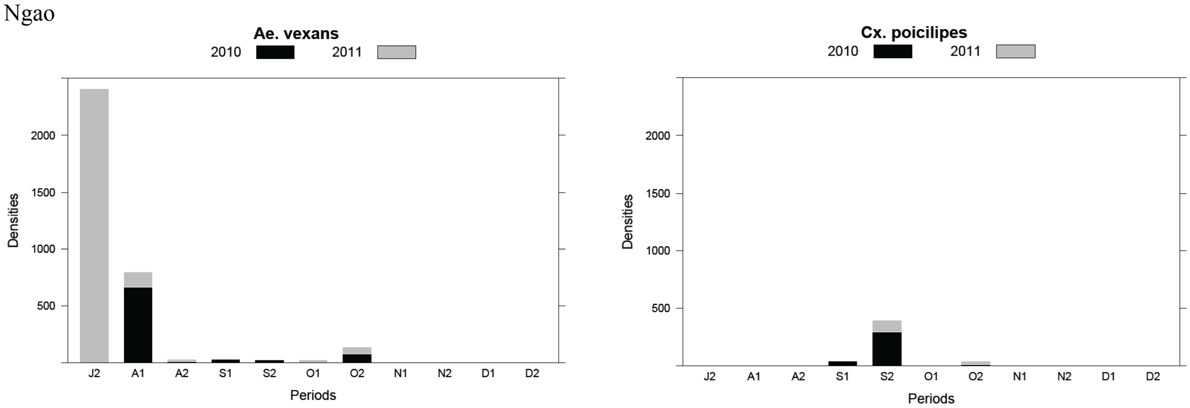


Figure 7: Temporal variations of *Ae. vexans* and *Cx. poicilipes* densities in the four ground pools studied

Host attractiveness

The attractiveness for human, sheep and goat to the two main vectors were studied near the main ground ponds using net-baited traps (Figure 8). Our findings showed that for *Ae. vexans* the highest densities were observed for goat (mean 15.6±28.2 mosquitoes per trap) and sheep (mean 5.52±11.68 mosquitoes per trap) whereas for *Cx. poicilipes*, human (mean 8.9±21.38 mosquitoes per trap) and sheep (mean 7.1±15.96 mosquitoes per trap) are more attractive. The mean densities were significantly different between the three hosts for *Ae. vexans* ($F=2.75$, $p<0.001$) and between human and goat ($p<0.001$) and sheep and human ($p=0.002$) whereas for *Cx. poicilipes* no significant difference was observed between the three hosts.

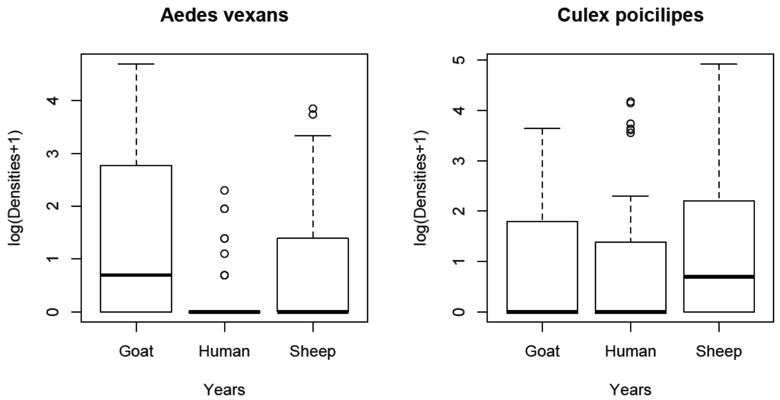


Figure 8: Comparative hosts attractiveness of *Ae. vexans* and *Cx. poicilipes*

Temporally, *Cx. poicilipes* and *Ae. vexans* were attractive to goat host during the study period, with the highest densities observed for *Ae. vexans*. For *Cx. poicilipes* human host, was more attractive from October to November. This species was also highly attractive to Sheep host at the same period. Attraction to Ae. vexans was observed at the beginning of the rainy season from July to early October with maximum densities observed at the beginning of the rainy season.

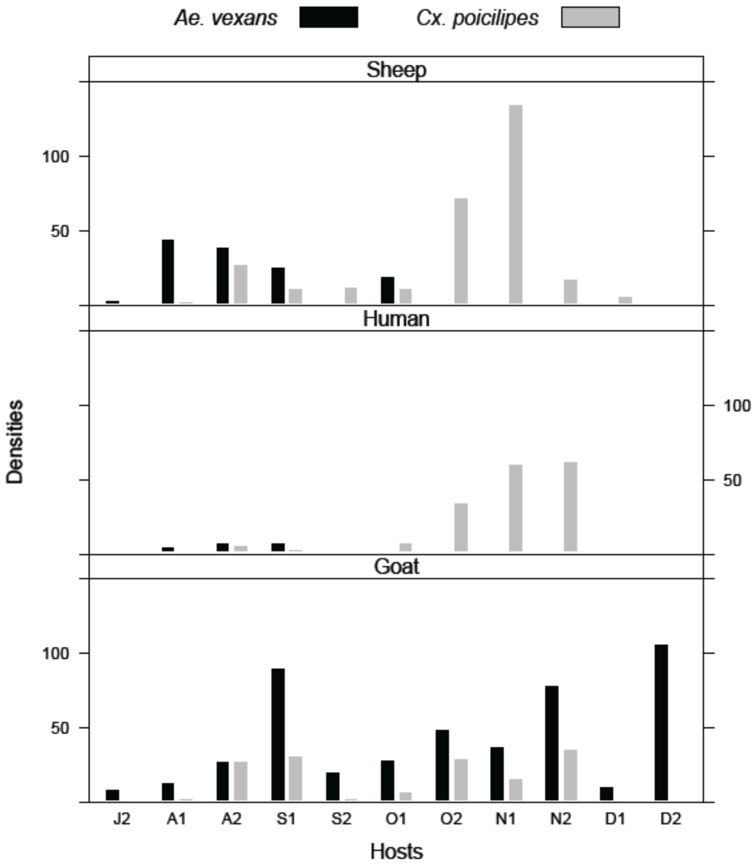


Figure 9: Temporal variations of the hosts attractiveness of *Ae. vexans* and *Cx. poicilipes*