

Night-time location and sleeping behaviour of households in northern Benin: implications for residual malaria transmission and vector control

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Abstract

Background

It is generally accepted that the declining effectiveness of core vector control tools — long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) — is partly explained by their misuse. Some household members remain outside, or move between indoor and outdoor spaces overnight, while sprayed walls and treated nets are designed to protect people who sleep indoors and under a net.

Methods

To determine whether communities that under-use these tools are more exposed to malaria vectors, direct participatory observation of household members' sleeping and activity patterns was carried out every 30 minutes from 19:00 to 07:00 in three departments of northern Benin. Binomial mixed-effects logistic regression (R 3.6, package lme4) was used to model the probability of household members being indoors versus outdoors as a function of season, time of night, collection area and IRS status, with household as a random effect.

Results

During the harmattan season, 95% of household members remained indoors from 19:00 to 07:00, compared with only 5% outdoors; this outdoor proportion declined steadily until 22:00. During the hot season, by contrast, 37% of households had members outdoors, with the majority remaining outside from 19:00 to 22:00. Household members were 4636 times more likely to stay indoors during the harmattan than during the hot season (adjusted odds ratio derived from $\beta = 8.44$). Populations in peripheral, non-IRS areas remained outdoors more than those in central, IRS-covered areas. Among household members exposed to bites outdoors, 65% cited irritation from indoor heat or insecticide as their main reason for staying outside, and 15% cited heat and lack of space. Overall, human exposure to *Anopheles gambiae* was higher outdoors than indoors, irrespective of the vector's host-feeding preferences.

Conclusion

Reducing residual malaria transmission will require raising community awareness of the correct use of LLINs and IRS, alongside complementary vector control tools designed for outdoor exposure.

Background

Malaria remains the most significant disease burden in the departments of northern Benin, with 128,261 cases reported in Alibori, 166,385 in Atacora and 159,083 in Donga [1]. Transmission is highest during the rainy season, typically from May to October [2]. Accordingly, the National Malaria Control Programme's (NMCP) strategic plan places particular emphasis on vector control, built around two

complementary interventions: the promotion of long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) [3].

In 2014, 1,290,000 people were protected by IRS campaigns organized by Benin's Ministry of Health; 5 million LLINs were distributed free of charge, and intermittent preventive treatment during pregnancy reached more than 1 million pregnant women [4]. Between 2012 and 2016, IRS coverage rates consistently exceeded 85%; in Atacora department alone, the population protected by IRS rose from 652,777 in 2012 to 858,113 in 2016 [5]. In 2017, a further 6,695,750 LLINs were distributed nationwide, and IRS was implemented as a complementary strategy in selected eligible municipalities of Alibori and Donga [6]. Over the same period, malaria incidence fell from 17% to 14.6% and case-fatality from 1.4 to 0.8 per 1,000 between 2012 and 2016 [7]. Despite this progress, malaria remains the leading cause of consultation and hospitalization (34%) in Benin, particularly among children under five and pregnant women, raising the question of why transmission remains high after decades of vector control investment.

Anopheles vectors in northern Benin are predominantly nocturnal, and night-time activity of the local population — including sleeping outdoors — may increase exposure to infective bites [8]. This raises two questions central to the present study: which night-time, malaria-risk behaviours persist despite the wide availability of vector control tools, and during which periods of the night are communities most vulnerable to infective Anopheles bites? Findings are intended to inform the design of behaviour-change communication and complementary interventions to reduce the risk of outdoor malaria transmission.

In this region, the primary malaria vectors have been confirmed by morphological and molecular (PCR) identification in published work from the Centre de Recherche Entomologique de Cotonou. Salako et al. showed that the Anopheles gambiae complex circulating across Alibori, Donga and Atacora comprises two sibling species living in sympatry — Anopheles coluzzii and Anopheles gambiae sensu stricto — with a higher blood-feeding rate recorded for *An. gambiae* s.s. than for *An. coluzzii* [18]. These same populations have also been characterized for insecticide-resistance markers (kdr L1014F, ace-1 G119S) relevant to the interpretation of vector control performance in the study area [18].

Methods

Study area

Benin is one of 17 countries funded under the PMI/AIRS project. The survey was conducted in three departments of northern Benin — Alibori and Donga (under IRS) and Atacora (post-IRS) (Fig. 1). Two communes were selected per department, and two sites were visited per commune: one from the central part of the commune and one from the periphery. In total, 96 households were followed:

Health zone (IRS status)	Districts	Households (n)
NBT (post-IRS)	Natitingou, Boukoumbé	32
KGS (under IRS)	Gogounou, Kandi	32
DCO (under IRS)	Djougou, Copargo	32

Household selection criteria

In each selected village, eight households were enrolled according to the following criteria: (i) at least five members, including adults and children or pregnant women; (ii) treated during the most recent IRS campaign, where located in Alibori or Donga; (iii) possession of at least one LLIN; (iv) presence of a member or parent trained to act as a data collector ("pollster"); and (v) spatial distribution across the site, with a minimum distance of 80 m between households.

Data collection techniques and tools

Direct observation, 19:00–07:00. Indoor and outdoor activities of every household member were recorded every 30 minutes throughout the night to identify practices favouring mosquito contact. Recorded activities included cooking, watching television, listening to the radio, resting, working at home, using a laptop or phone, listening to music, eating, sleeping without a net, sleeping under a net, socializing, playing, praying, washing dishes and bathing. A standardized form was used to record each member's activity and location (indoors or outdoors) at each time point (Fig. 2).

Qualitative data. A qualitative questionnaire was administered to adult household members to capture their perceptions of the available vector control tools and the factors limiting LLIN use.

Data processing hardware and software. Geographic coordinates of surveyed localities were recorded using GPS Track Maker (Odilon Ferreira Junior) and DNR Garmin software. Indoor and outdoor behaviours were compared between communes with and without IRS, to inform behaviour-change communication and complementary interventions against outdoor malaria transmission. Quantitative and qualitative data on activities and location were collected every 30 minutes from 19:00 to 07:00 for each household member enrolled.

Statistical analysis

Binomial mixed-effects logistic regression was used to model the probability of a household member being indoors versus outdoors as a function of collection area, IRS status and collection time (fixed effects), with household included as a random effect. Analyses were performed in R 3.6 using the lme4 package.

Mosquito collection on human landing catches

In each commune, a central and a peripheral zone were selected. Monthly human landing catches were performed hourly from 19:00 to 07:00 by volunteer subjects who had provided prior informed consent, using haemolysis tubes. Two nights of collection were organized per month before, during and after the cessation of IRS, from January to May 2018. Two collection points were selected per zone in each commune. Recorded data were used to estimate human biting density (bites per person per hour).

Captured *Anopheles* specimens were identified to species/complex level using standard morphological taxonomic keys. Molecular (PCR) confirmation of sibling species within the *An. gambiae* complex (*An. coluzzii* vs *An. gambiae* s.s.) and sporozoite ELISA testing were not performed as part of this study, whose primary objective was to characterize human behavioural exposure rather than vector population genetics. This choice was made because the species composition, sibling-species proportions and insecticide-resistance profile of *An. gambiae* s.l. populations at these same sites had already been independently established by PCR in concurrent CREC entomological surveillance in Alibori and Donga [18]. All entomological results in this manuscript are therefore reported at the *An. gambiae* s.l. (complex) level, and should be interpreted alongside that companion molecular dataset rather than as a self-contained species-level analysis.

Results

Distribution of household members' position from 19:00 to 07:00

This analysis considered the position of household members in the selected villages during the harmattan and hot seasons. The harmattan is a warm, dry wind blowing from the Sahara over West Africa; conditions are hot during the day and cold at night. During the harmattan season, 95% of household members remained in their rooms from 19:00 to 07:00, and only 5% were outdoors during the same interval, with the outdoor proportion declining steadily until 22:00. By contrast, during the hot season, more households had members outdoors (37%), as shown in Fig. 3. Across both seasons, most households — regardless of location — did not sleep under a mosquito net and were therefore exposed to bites.

To identify the time intervals during which household members were indoors, each member's location was recorded every 30 minutes; results are shown in Fig. 3a and 3b. According to Fig. 3a, during the harmattan season fewer than 20% of household members were outdoors between 19:00 and 19:30, and this proportion declined gradually until 22:00, when essentially all members were indoors. From 05:30, members began to step outside again, reaching 10% outdoors by 07:00. Fig. 3b shows the contrasting pattern during the hot season: the majority of household members remained outdoors from 19:00 to 22:00, moving indoors only gradually from 22:30 onward; throughout the night, some members remained outdoors carrying out various activities.

Influence of season, level of urbanization and IRS area on household members' position

In the binomial generalized mixed model, household was the sole source of random variability, representing the random sampling unit used to estimate the probability of a member being indoors or outdoors. The variance of the random effect ($\sigma^2 = 8.507$) indicated limited dispersion around the response variable, supporting general inference about the wider population independent of any particular household. All fixed effects in the model were highly significant (Table 1). Regarding time of night, respondents were more likely to be indoors between 00:00 and 06:00, and were ten times more likely to be indoors between 04:00 and 04:30 than at other times; from 06:00 onward, the population increasingly moved outdoors, with the highest likelihood of being outside between 06:00 and 06:30. Regarding season, household members were 4636 times ($e^{\beta}=e^{8.44}$) more likely to remain indoors during the harmattan than during the hot season. Members of households in peripheral collection areas were more likely to remain outdoors than those in central areas, and members of non-IRS households were more likely to remain outdoors than those in IRS-covered households (Table 2).

Table 1 Results of the binomial mixed-effects logistic regression model

Variable	Estimate	Std. Error	z value	Pr(> z)	Sig.
(Intercept)	1.82542	0.09617	18.982	$<2 \times 10^{-16}$	***
Time 7:00–7:30 pm	-6.09911	0.09891	-61.661	$<2 \times 10^{-16}$	***
Time 7:30–8:00 pm	-5.54869	0.09572	-57.969	$<2 \times 10^{-16}$	***
Time 8:00–8:30 pm	-4.85249	0.09158	-52.986	$<2 \times 10^{-16}$	***
Time 8:30–9:00 pm	-4.16575	0.08803	-47.322	$<2 \times 10^{-16}$	***
Time 9:00–9:30 pm	-3.68250	0.08569	-42.974	$<2 \times 10^{-16}$	***
Time 9:30–10:00 pm	-3.03815	0.08360	-36.340	$<2 \times 10^{-16}$	***
Time 10:00–10:30 pm	-2.14864	0.08183	-26.258	$<2 \times 10^{-16}$	***
Time 10:30–11:00 pm	-1.68425	0.08155	-20.653	$<2 \times 10^{-16}$	***
Time 11:00–11:30 pm	-1.15267	0.08205	-14.048	$<2 \times 10^{-16}$	***
Time 11:30 pm–00:00 am	-0.59672	0.08347	-7.149	8.76×10^{-13}	***
Time 00:30–1:00 am	0.42630	0.08952	4.762	1.92×10^{-6}	***
Time 1:00–1:30 am	0.88172	0.09386	9.394	$<2 \times 10^{-16}$	***
Time 1:30–2:00 am	1.18299	0.09735	12.152	$<2 \times 10^{-16}$	***
Time 2:00–2:30 am	1.52032	0.10171	14.947	$<2 \times 10^{-16}$	***
Time 2:30–3:00 am	1.74050	0.10482	16.605	$<2 \times 10^{-16}$	***
Time 3:00–3:30 am	2.12976	0.11056	19.264	$<2 \times 10^{-16}$	***
Time 3:30–4:00 am	2.25621	0.11245	20.065	$<2 \times 10^{-16}$	***
Time 4:00–4:30 am	2.30458	0.11316	20.366	$<2 \times 10^{-16}$	***
Time 4:30–5:00 am	2.25286	0.11241	20.042	$<2 \times 10^{-16}$	***
Time 5:00–5:30 am	1.97984	0.10835	18.273	<0.001	***
Time 5:30–6:00 am	1.32771	0.09937	13.361	$<2 \times 10^{-16}$	***
Time 6:00–6:30 am	-0.53565	0.08378	-6.393	1.62×10^{-10}	***
Time 6:30–7:00 am	-1.90849	0.08119	-23.507	$<2 \times 10^{-16}$	***
Season: Harmattan	8.44169	0.11790	71.599	$<2 \times 10^{-16}$	***
Peripheral collection area	-0.33800	0.09660	-3.499	0.000467	***
IRS / non-IRS	-0.72724	0.11961	-6.080	1.20×10^{-9}	***

Table 2 Odds ratios and 95% confidence intervals

Variable	Odds ratio	Lower limit (95% CI)	Upper limit (95% CI)
(Intercept)	6.205	5.139	7.493
Time 7:00–7:30 pm	0.002	0.002	0.003
Time 7:30–8:00 pm	0.004	0.003	0.005
Time 8:00–8:30 pm	0.008	0.007	0.009
Time 8:30–9:00 pm	0.016	0.013	0.018
Time 9:00–9:30 pm	0.025	0.021	0.030
Time 9:30–10:00 pm	0.048	0.041	0.056
Time 10:00–10:30 pm	0.117	0.099	0.137
Time 10:30–11:00 pm	0.186	0.158	0.218
Time 11:00–11:30 pm	0.316	0.269	0.371
Time 11:30 pm–00:00 am	0.551	0.468	0.648
Time 00:30–1:00 am	1.532	1.285	1.825
Time 1:00–1:30 am	2.415	2.009	2.903
Time 1:30–2:00 am	3.264	2.697	3.950
Time 2:00–2:30 am	4.574	3.747	5.583
Time 2:30–3:00 am	5.700	4.642	7.000
Time 3:00–3:30 am	8.413	6.774	10.448
Time 3:30–4:00 am	9.547	7.658	11.901
Time 4:00–4:30 am	10.020	8.027	12.508
Time 4:30–5:00 am	9.515	7.633	11.860
Time 5:00–5:30 am	7.242	5.856	8.955
Time 5:30–6:00 am	3.772	3.105	4.584
Time 6:00–6:30 am	0.585	0.497	0.690
Time 6:30–7:00 am	0.148	0.126	0.174
Season: Harmattan	4636.384	3679.772	5841.682
Peripheral collection area	0.713	0.590	0.862
IRS / non-IRS	0.483	0.382	0.611

Household members' exposure indoors under a net and outdoors without a net, relative to *An. gambiae* density

Hot season

Human and *An. gambiae* behavioural activity outdoors (without a net) was compared with that of residents indoors (with a net) across the night during the hot season (Fig. 4). At dusk, high human mobility both indoors and outdoors coincided with low mosquito aggressiveness in both settings. As mobility declined after 21:00 – as members settled into resting, eating, studying, following television or radio, and sleeping with or without a net – *An. gambiae* aggressiveness rose sharply, more markedly outdoors than indoors, peaking after 01:00. Despite low outdoor activity at this hour, outdoor aggressiveness remained higher than indoors, with a mean difference of 0.87 bites per person per hour, before gradually declining as morning activity resumed.

High indoor human activity was observed from 19:00 to 22:30 and again from 04:00 onward, with 22:30 to 04:00 representing the main rest period under nets for most household members. *An. gambiae* aggressiveness indoors and outdoors rose slightly during the first two hours after 19:00, then markedly until it peaked around 01:00, before gradually declining until 07:00. Throughout the night, outdoor aggressiveness against unprotected individuals exceeded indoor aggressiveness.

Harmattan season

From December to January, mean *An. gambiae* density was markedly higher indoors than outdoors. Aggressiveness at dusk was substantially higher indoors than outdoors, with a difference of about 0.55 bites per person per hour (Fig. 5). Indoor aggressiveness then declined, while outdoor aggressiveness rose slightly for about an hour before converging with indoor levels. Overnight, aggressiveness indoors and outdoors oscillated between 0.02 and 0.2 bites per person per hour, with a small indoor excess. Most household members were under a net from 23:00 onward. From 05:00, indoor aggressiveness increased sharply, with a smaller increase outdoors.

Causes of outdoor exposure to bites

Because exposure to mosquito bites is closely linked to household members' position relative to sprayed rooms, the reasons for outdoor exposure were examined. Irritation from indoor spraying or netting was cited by 65% of exposed household members as their main reason for remaining outdoors, and 15% cited heat and lack of indoor space.

Discussion

This study characterizes household members' exposure to bites in relation to their nocturnal location during the harmattan and hot seasons in northern Benin. These two seasons differ markedly in climatic

conditions, which in turn shape both sleeping behaviour and the availability of malaria vectors.

During the harmattan season, 95% of household members remained indoors from 19:00 to 07:00, with only 5% outdoors over the same interval, a proportion that declined steadily until 22:00. During the hot season, by contrast, more household members remained outdoors, particularly from 19:00 to 22:00, moving indoors only gradually from 22:30. Across both seasons, most household members – irrespective of position – did not sleep under a net and were consequently exposed to bites. This pattern is largely attributable to elevated indoor temperatures during the hot season, which push people outdoors, sometimes until late at night.

These findings echo those of Monroe et al., who reported frequent outdoor biting exposure at both of their study sites [8]. Although household members recognized LLINs as an important malaria-prevention tool, observed net use was low for both indoor and outdoor exposure. The breadth of outdoor sleep and other night-time activities observed here could substantially increase malaria risk, suggesting that indoor-oriented control measures such as LLINs and IRS alone are insufficient to interrupt transmission, particularly in children.

Dunn et al. found that shifts in sleep patterns driven by socio-cultural events and livelihood activities in southern Tanzania affected LLIN use [11]. Similarly, Matowo et al., also in southern Tanzania, described night-time and dawn activity patterns comparable to those observed here, overlapping with the biting activity of *Anopheles arabiensis* and *Anopheles funestus* [12], underscoring the importance of accounting for livelihood- and culture-driven sleep patterns. A study in Uganda identified social, logistical and access-related barriers to outdoor bite protection, including attendance at funeral services as a notable constraint on LLIN use [13]. These results are consistent with Moshi et al. (2017), who found that participants were more frequently bitten outdoors in the evening than indoors, largely because of housework that could not be performed indoors, poor housing ventilation and warm conditions; participants reported wearing long-sleeved clothing and trousers, using repellents, and burning cow dung or neem leaves to deter mosquitoes [14].

Overall, because of household member mobility and vector behaviour, human exposure to *An. gambiae* was higher outdoors than indoors, regardless of the vector's host-feeding preferences [15]. During the harmattan season, household members were 4636 times more likely to remain indoors than during the hot season, and populations in peripheral, non-IRS areas remained outdoors more than those in central, IRS-covered areas. These findings parallel those of Kané et al., who reported that malaria prevalence rose by 220% (from 14% to 42%) between June and October in a non-IRS zone in Mali, compared with a much smaller increase (from 9.2% to 13.2%) in an IRS zone [16]; Kaplan–Meier survival analysis in the same study showed that children in the IRS zone remained malaria-free significantly longer (hazard ratio 0.45, 95% CI 0.37–0.54) than children in the non-IRS zone. Together, these results support the development of complementary control measures targeting outdoor exposure during vector-biting hours [17].

Limitations

Several limitations should be considered when interpreting these findings. First, direct observation by a resident "pollster" may have altered household members' usual behaviour (observer/Hawthorne effect), potentially leading to an under- or over-estimate of true outdoor exposure. Second, the study was restricted to three departments of northern Benin over a limited number of nights per season, which may limit generalizability to other epidemiological or ecological settings, including southern Benin. Third, season and IRS status were not fully independent in the sampling design – IRS/post-IRS status was assigned by department and hot-season versus harmattan-season data were collected in different periods – so residual confounding between season, geographic area and IRS status cannot be excluded. Fourth, this study relied on morphological identification of *Anopheles* specimens and did not itself perform molecular (PCR) confirmation of sibling species within the *An. gambiae* complex, nor did it measure sporozoite infection rates; as explained in the Methods, this was a deliberate scope choice given the study's behavioural focus, and these parameters – needed to translate the observed exposure patterns into a species-specific entomological inoculation rate – are instead available from companion CREC molecular studies conducted at the same sites [18]. Results here should accordingly be interpreted at the *An. gambiae s.l.* level and read alongside that companion dataset. Finally, no a priori sample-size or power calculation was reported for the 96 households enrolled.

Recommendations to the National Agency for Malaria and Mosquito Control (ANLMM) and the Ministry of Health of Benin

Since 2021, no department of northern Benin has retained active IRS coverage – withdrawn from Atacora in 2019/2020 and from Alibori and Donga in 2021 after four years of implementation – leaving long-lasting insecticidal nets (LLINs) as the only mass vector control tool currently deployed in the study area. In this context, the following three evidence-based recommendations follow directly from the present findings.

First, complementary vector control tools targeting outdoor (exophilic/exophagic) exposure should be reintroduced or prioritized in Alibori, Donga and Atacora. Outdoor *An. gambiae* aggressiveness exceeded indoor aggressiveness even during years of active IRS, and the complete withdrawal of IRS since 2021 – together with the documented five-fold rise in entomological inoculation rate observed after IRS withdrawal in Atacora – indicates an urgent need for exophilic interventions (spatial repellents, larviciding, and dual-action LLINs) to offset the current absence of indoor residual protection.

Second, behaviour-change communication should specifically target the night-time window and drivers of outdoor exposure identified here – the 19:00–22:00 period during the hot season, when 65% of exposed household members cited indoor heat or insecticide irritation as their main reason for remaining outdoors. Campaigns should promote correct LLIN use, including net use while sleeping outdoors, alongside simple household-level measures to improve indoor ventilation, so as to maximize the protective value of LLINs, now the only mass tool still deployed in these departments.

Third, Larval Source Management (LSM) using drone-based larviciding should be extended to temporary and otherwise inaccessible breeding sites, particularly the seasonally flooded plains and rice-growing areas of Alibori, Donga and Atacora during the rainy season. Because LSM targets the immature (larval) stage rather than the biting adult, its effectiveness does not depend on household members' night-time location or LLIN/IRS uptake — the principal behavioural gap identified in this study — making it a mechanistically independent complement to LLINs. Aerial application allows rapid, homogeneous coverage of extensive or flooded breeding sites that are difficult to reach on foot, consistent with WHO guidance recommending LSM as a supplementary intervention where breeding sites are few, fixed and findable; site mapping and stability should first be confirmed locally before scale-up.

Conclusions

This study demonstrates marked spatio-temporal heterogeneity in outdoor sleep and night-time activity between IRS and non-IRS areas, with spatial variation exceeding temporal variation. Future entomological studies should incorporate parallel research on human behaviour, using a standardized approach to monitor human–vector interaction and the protection gaps left by LLINs and other vector control interventions across settings and over time. Such evidence is essential to strategically target existing tools, design effective social- and behaviour-change interventions, and deploy complementary prevention tools suited to outdoor exposure.

Declarations

Ethics approval and consent to participate

Permission was obtained from households prior to data collection in their rooms, and community consent was secured beforehand in all villages. Field investigators provided informed consent before participating in the study, underwent regular medical check-ups with preventive antimalarial treatment, and were vaccinated against yellow fever. The study was approved by the Ethical Institutional Committee of the Centre de Recherche Entomologique de Cotonou (CREC), Ministry of Health, Benin.

Consent for publication

Not applicable.

Availability of data and materials

The data supporting the conclusions of this article are included within the article. The raw datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AS, FA, RA, LN and MCA conceived and designed the study. AS, GP, ASS and MCA contributed to protocol design. SBB, EO, ASS, FA and BA collected entomological and behavioural field data. RA, ASS, FA and BA carried out laboratory analyses. GP and CH contributed to spatial data analysis and mapping. FD contributed to the programmatic interpretation of the findings. DG and MCA drafted the manuscript. FA, BA, AS, FD, CH and MCA critically revised the manuscript for intellectual content. All authors (AS, GP, SBB, FD, RA, LN, BA, ASS, FA, DG, EO, CH, MCA) read and approved the final manuscript.

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Figures

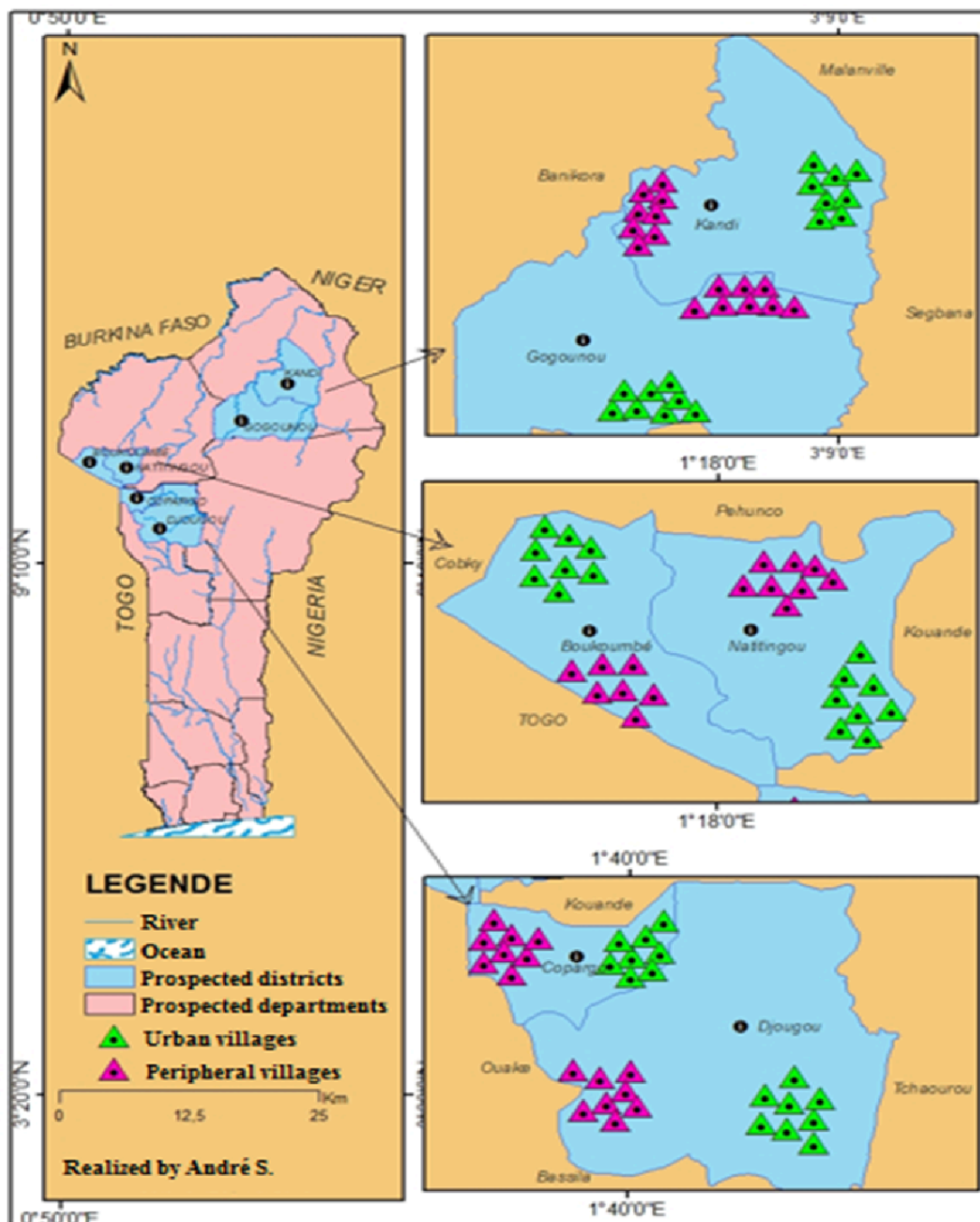


Figure 1: Map of the study area showing selected households

Figure 1

See image above for figure legend.



Figure 2: Pollster marking the observation sheet of household members already sleeping from 9:00 pm during the hot weather season in Kataban, Copargo

Figure 2

See image above for figure legend.

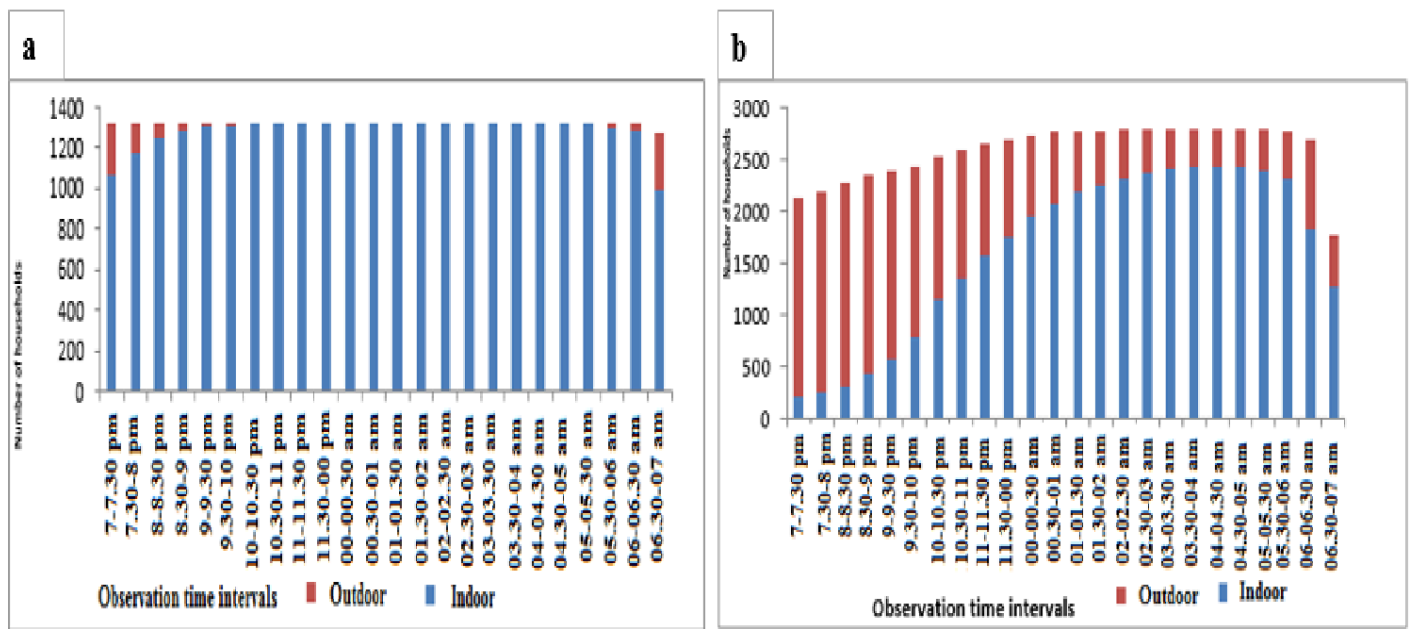


Figure 3: Distribution of the population according to their position from 7:00 pm to 7:00 am during the harmattan season (a) and hot weather season (b).

Figure 3

See image above for figure legend.

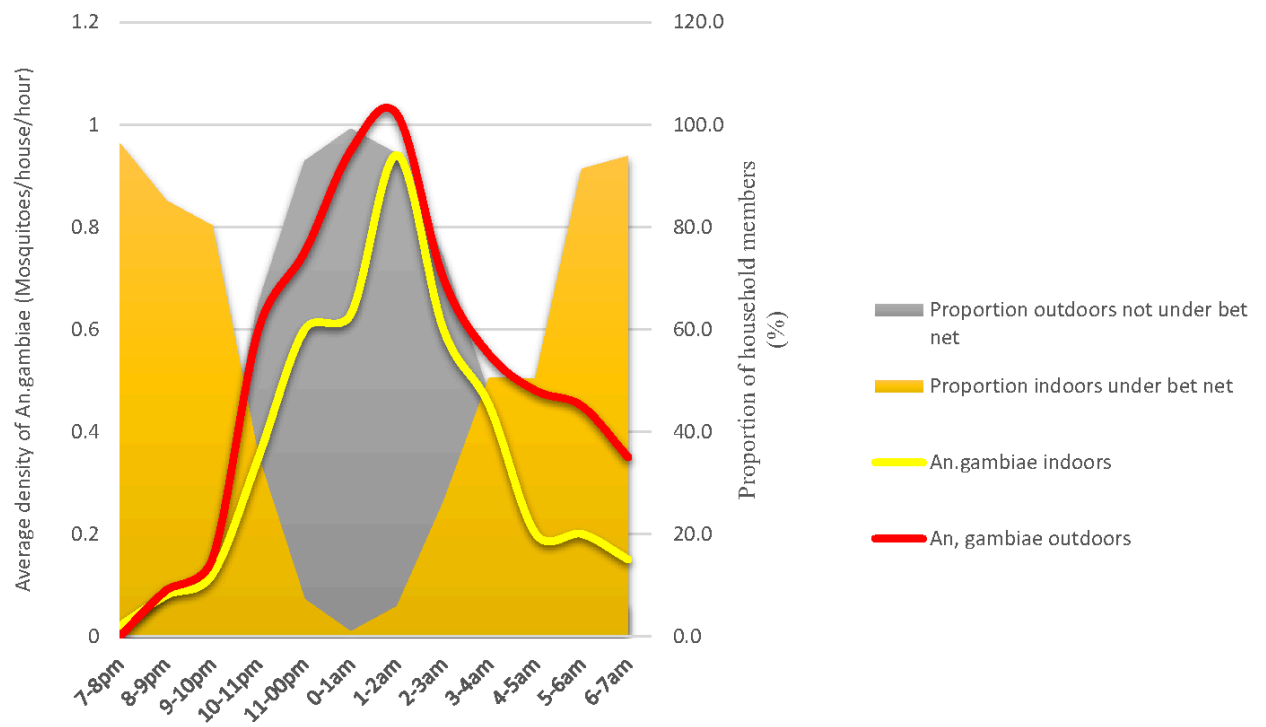


Figure 4: Illustration of human behavioural activities outside households in the absence of the net and under the net within households in relation to the aggressiveness of *An. gambiae* mosquitoes, measured at different night time intervals during hot periods.

Figure 4

See image above for figure legend.

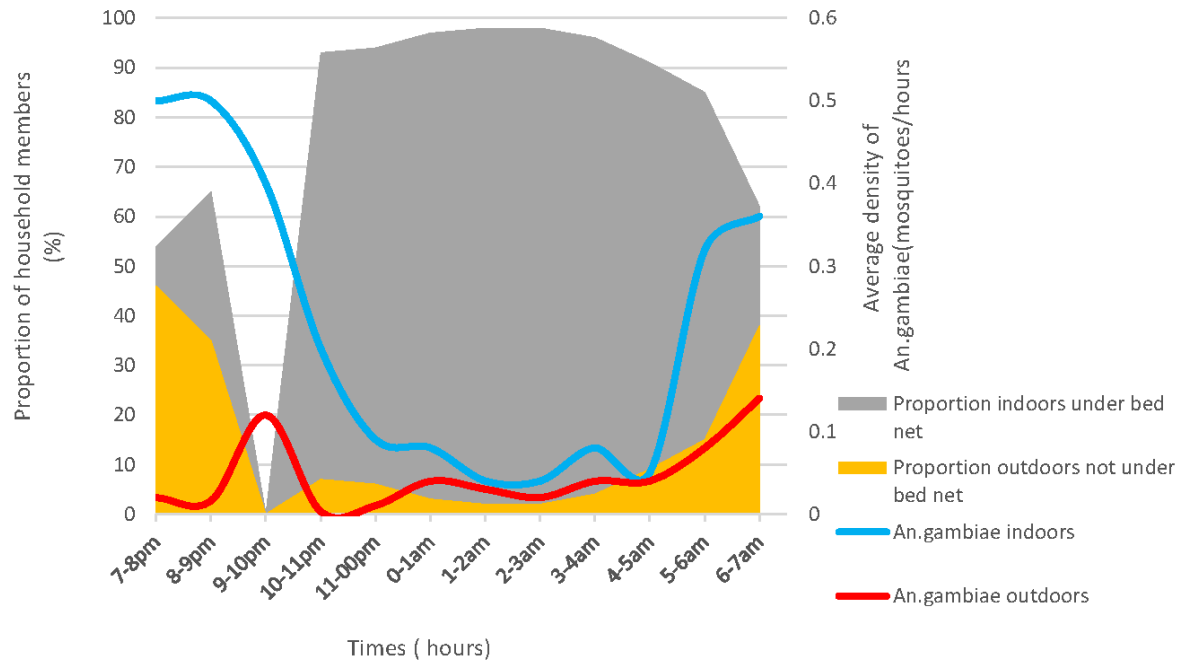


Figure 5: Illustration of human behavioural activities outside households in the absence of the net and under the net within households in relation to the aggressiveness of *An. gambiae* mosquitoes, measured at different night time intervals during the harmattan.

Figure 5

See image above for figure legend.