Risk of vector-borne diseases in relation to rubber plantations in Côte d'Ivoire as compared to Lao PDR.

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Background:

The ECOMORE project has given great insight into the risks of vector-borne disease transmission in rubber plantations of northern Lao PDR. The importance of rubber plantation habitats for the dynamics for vector-borne diseases is an issue that also needs to be considered for other areas in the world where rubber plantation habitats are common. As far as we are aware no studies have been conducted on the risk of vector-borne diseases in rubber plantations outside South-east Asia (SEA), except of an onchocerciasis risk study among residents of a rubber plantation in Liberia [53, 54]. With growing evidence of increased vector-borne disease risk in rubber plantations of SEA, it is of interest to identify the vector-borne disease dynamics in rubber plantation areas established in Africa and South America. This is especially pressing in sub-Saharan Africa where vector-borne diseases such as malaria and yellow fever still result in a high number of morbidity and mortality [55, 56]. .

Rationale:

Côte d'Ivoire has the largest area of rubber plantation in the whole of Africa. We anticipate that the changes in the environment to rubber cultivation is resulting in an altered risk from vector-borne diseases for the local population with increased risk of exposure to vector mosquitoes for the rubber workers and their families; predominantly malaria and yellow fever, but also arboviral diseases such as dengue and chikungunya. This study will provide an opportunity to further develop the entomological department at Institut Pasteur de Côte d'Ivoire whilst deepening our understanding of the vector ecology in rubber plantations in West Africa. Furthermore this data will be combined with data collected in a similar fashion in Lao PDR to write a comprehensive document about the vector-borne disease risks for rubber workers. It is envisaged that this project will allow us to advise different governmental and health organizations how to decrease vector-borne disease incidence in rubber plantation areas where active transmission of vector-borne diseases already occurs. For this purpose we will also be comparing commercially available personal protection methods in the field both for their protectiveness from mosquitoes and acceptance by the local population. This study will be of relevance to public health workers, governments and those working in the rubber industries of Côte d'Ivoire, other countries in West Africa and SEA. The goal of this study is to assess the potential risk of vector-borne disease infections occurring in and around rubber plantations.

The study objectives are:

1. Determine the risk of mosquito-borne diseases like malaria, yellow fever, dengue and chikungunya arising in rubber plantations compared to surrounding villages
2. Understand when and where rubber plantation workers are exposed to the vector mosquitoes
3. Provide advice on how to decrease exposure of rubber plantation workers, their families and the local population to vector-borne diseases
4. Understand the differences and similarities between Laos and Côte d'Ivoire in vector-borne disease risk in rubber plantation

Update until October 2016:

During the last year the Yersin team has spent considerable time in the field, both in Côte d'Ivoire and in Lao PDR. In Côte d'Ivoire the team has continued its successful adult mosquito data collection in the field which was started in December 2015. In Lao PDR during two months of intense fieldwork, data has been collected on the protectiveness of different personal protection methods. In the following paragraphs we will go into detail on our activities in both countries for this project.

Côte d'Ivoire:

Since the start of the fieldwork in December 2015 adult mosquito collection in Côte d'Ivoire have been conducted successfully for 10 months in the three study sites, each consisting of four different habitats (mature rubber plantation, immature rubber plantation, village surrounded by rubber plantations and villages without plantations in the area). Two more months of adult mosquito collection are planned until November 2016, after which data can be fully analysed. Until July 2016 (8 months) a total of 5,451 female mosquitoes and 1,030 male mosquitoes have been collected using the human-baited double net (HDN) trap. The preliminary data highlights the high density of mosquitoes collected in the mature rubber plantations (n=1,117), immature rubber plantations (n=1,684) and villages away from the plantations (n=1,979). Low numbers have been collected in the villages surrounded by rubber plantations (n=671). This data gives a first insight into the importance of rubber plantations as mosquito habitats. However this does not result in information regarding the risk of vector-borne diseases, with not all mosquitoes able to transmit diseases. In the paragraph below we focus on the three most important and abundant vector mosquito species collected in the field.

We have summarized the data of the first eight months of collection for the important malaria, yellow fever and lymphatic filariasis vectors to give insight into the data collected. The most abundant malaria vector *Anopheles gambiae* s.l. was collected a total of 61 times. The malaria vector seems more prevalent in the villages than in the rubber plantations with more than half of the samples collected from the villages surrounded by rubber plantations. The vector was mostly active from 22.00 to 02.00 O’clock when villagers were asleep. Contrary to the malaria vector, the density of the yellow fever and dengue vector *Aedes aegypti* was highest in mature and immature rubber plantations where 95% of the total 1,402 *Aedes aegypti* samples were collected. The vector was active throughout the day with a peak from 16.00 to 18.00 O’clock. A total of 2,031 *Culex quinquefasciatus* mosquitoes have been collected during the first eight months of collection. This important vector of lymphatic filariasis was generally collected in high numbers from the villages away from the rubber plantations. Peak collection period was from 19.00 to 22.00 O’clock when villagers were preparing to go to sleep. The preliminary results presented here give a first insight into the data. The vector presence and behaviour will be analysed at the end of 2016 when data is complete.

Apart from the adult mosquito identification we are also analysing the collected vector samples for parity rate of the ovaries, which gives an indication of the survival rate of the mosquitoes. Using this survival rate we can identify the longevity of the mosquitoes, with long living vector mosquitoes resulting in more effective disease vectors. After collection of adult mosquitoes has been completed in December 2016 we will use both the adult mosquito prevalence and survival rate for calculations of the basic reproductive number (R0) which gives an indication of the number of infections one disease case can generate on average during the course of its infectious period in a certain habitat. If the basic reproduction number is for example two, this entails that one infective human case can result in two new infective human cases. The higher the basic reproductive number in a habitat, the higher the risk the disease establishes itself in the habitat.

Rapid rural appraisals have been conducted in November 2015 to assess the knowledge among villagers regarding vector-borne diseases and to extract general behavioural patterns of the villagers and rubber workers. Currently we are in the process of conducting tri-monthly surveys in the field to collect additional data on the behaviour of the local villagers and rubber workers in the different habitats throughout the year. Using the results from both the rapid rural appraisals and surveys we will identify several common behavioural patterns. The combination of the human behaviour data and entomological data will enable us to identify risky behaviour for vector-borne diseases. This information will be used to inform the government and local population on when and where villagers and rubber workers are exposed to vector-borne diseases, risky behaviour and how to mitigate these risks.

The knowledge on how to mitigate vector-borne disease risk alone is not enough to decrease vector-borne disease incidence. It is important to identify how we can communicate our recommendations to the local populations. To identify the best methods with which we can reach the local population, we will conduct several focus group discussion in the study area. We have identified social scientist students from the local university to help conduct these discussions and analyse the data. We are currently in the process of writing the standard Operating Procedure (SOP) which will be implemented in the field in 2017.

Next year we plan to collect data on the breeding sites of the important vector species identified during the adult mosquito survey. We are currently updating the SOP of the larval survey. The survey will be conducted throughout 2017 in the same habitats where adult surveys are currently taking place. The identification of the main waterbodies where mosquitoes breed, will be used to design vector control strategies and and write recommendations on how to decrease vector numbers in the area.

Lao PDR:

In July 2016 we received the approval from all ethical committees (Institut Pasteur Paris, Durham University and the Lao government) for our personal-protection methods comparison study. We started our fieldwork at the end of July 2016 in northern Lao PDR. For 8 weeks we worked in the field to collect adult mosquitoes using five treatments and two untreated controls (Table 1). Collections were conducted using human landing catches for 6 consecutive hours in villages at night and in forested areas during the day. A total of 14 comparison days and 28 comparison nights were done. A total of 32 participants were involved, whom all received a long lasting insecticide-treated net and relevant health insurances. Furthermore participants were paid for their work collecting mosquitoes. All collected mosquitoes have already been identified to species. We are now in the process of entering all data in digital files for analysis. During the next trimester focus will be on cleaning the data and analysing the results for recommendations.

Table 1: The five treatments and two controls of the comparison study

No.	treatment	Length of overall trousers	treatment	Other anti-mosquito measures
i		Short	Treated with 0.52% permethrin	
ii		Long	Treated with 0.52% permethrin	
iii		Short	Untreated^	CARE PLUS anti-insect natural spray 40% CITRIODIOL*
iv		Short	Treated with 0.52% permethrin	CARE PLUS anti-insect natural spray 40% CITRIODIOL*
v	Control	Short	Untreated^	Metofluthrin coils with 0.015% active ingredient from Fumakilla (Thailand) LTD
vi	Control	Short	Untreated^	
vii		long	Untreated^	

All untreated clothing has gone through the same procedure (i.e. factory dipping) but without the active ingredient for fair comparison.* was applied once to exposed skin during the six hour collection period. Repellent was applied by the responsible (i.e. Julie-Anne Tangena) at a rate of four dose (sprays) per limb to decrease variation of application among participants

Apart from understanding which method protects people from mosquito bites, it is important to understand the user friendliness of the products. In the beginning of September 2016 we conducted 28 surveys among the participants of the comparison study to identify their preference. We not only asked them which method protected them from mosquito bites, but also which method was most comfortable and easy to wear. We also asked them about their monthly investment in personal protection methods to understand the availably finances in each household for the purchase of personal protection methods. With this information we hope to assess the acceptability of the personal protection methods in our study area. We are currently analysing this data.

In August 2016 we conducted 12 focus group discussions with the help of two social scientist students from Vientiane University. Focus group discussions were conducted with young boys (< 20 years), young girls (< 20 years), male adults (20-35 years), female adults (20-35 years), old male adults (> 35 years) and old female adults (> 35 years). In small groups the local villagers were asked to share their experience and knowledge of mosquitoes and mosquito-borne diseases. Furthermore we asked them about the current methods used by the government to communicate information to the local villagers (eg. meetings, posters, radio spots, t-shirts) and which methods they preferred. The focus group discussions are currently being transcribed and translated. Data will be analysed for trends.

Communication:

Every three months the Yersin team has been writing a newsletter on the activities of this project. This newsletter is written for distribution by the Michelin Corporate Foundation to inform people outside the scientific world on the project. This two page newsletter includes a roadmap, updates from the field and preliminary results. We will continue writing newsletters every three months until the end of the project.

A representative of the Michelin Corporate Foundation, Mister Phillipe Legrez, visited the Ivorian and Lao team in Côte d’Ivoire from the 27^{th} to the 29^{th} of January 2016 to discuss the project achievements so far and to see the Yersin activities in the field. The HDN trap was clarified and presented in the field. Additionally in each of the three study villages a small meeting was held with the village head, village elderly and study participants to talk about the project and its impact on the village. Furthermore the district health centre was visited to understand the impact of mosquito-borne diseases on people living in the area and how they are helped. All in all, the visit of Mr. Legrez was a great opportunity for the project team to show the progress of the project and a great opportunity to discuss the project in detail to ensure the goals and objectives of the project are met.

The research director from the Ministry of Research Côte d’Ivoire, director of the National Institute of Hygiene Côte d’Ivoire, representative of the National Center of Agricultural Research (CNRA), Ivorian entomologists and other representatives from the research field were present to witness the official opening. The research director from the Ministry of Research, the director of Institut Pasteur de Côte d’Ivoire Pr. Dosso and Mr. Legrez gave a small talk on the impact of the Yersin project. A balafong band provided music during the ceremony. After the ceremony the ribbon of the building was cut and everyone received a short tour of the building. On the whole the inauguration ceremony provided us with a great opportunity to highlight the Yersin project to the research and government community of Côte d’Ivoire.

Future activities:

In 2017 the focus of the Yersin project will be on both the analysis of data collected in 2016 and conducting additional field work. The data analysis will consist of entering the data, cleaning the data and using statistical analysis to investigate the data. The data will be used to write scientific papers and the conclusions from these papers will be communicated as recommendations to the local populations and health offices in the region. The field work in 2017 will mainly take place in Côte d’Ivoire with both a larval survey and social study planned for next year.

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