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Review

Risk and Control of Mosquito-Borne Diseases in Southeast Asian Rubber Plantations

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Unprecedented economic growth in Southeast Asia (SEA) has encouraged the expansion of rubber plantations. This land-use transformation is changing the risk of mosquito-borne diseases. Mature plantations provide ideal habitats for the mosquito vectors of malaria, dengue, and chikungunya. Migrant workers may introduce pathogens into plantation areas, most worryingly artemisinin-resistant malaria parasites. The close proximity of rubber plantations to natural forest also increases the threat from zoonoses, where new vector-borne pathogens spill over from wild animals into humans. There is therefore an urgent need to scale up vector control and access to health care for rubber workers. This requires an intersectoral approach with strong collaboration between the health sector, rubber industry, and local communities.

Mosquito-borne Diseases in SEA

In **SEA** (see Glossary) the most important **vector**-borne diseases are **malaria** and **dengue**. The World Health Organisation (WHO) estimates that from 2000–2014 there was a reduction in global malaria cases from 2.9 million to 1.6 million, with malaria mortality rates falling by 60% [1]. The malaria mortality rate declined by 85% in the SEA region and by 65% in the Western Pacific region (Figure 1A). This remarkable decline has been achieved by the massive deployment of long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), improved access to diagnosis, and effective treatment with **artemisinin combination therapies (ACTs)** [1]. Consequently, many countries in SEA are now planning for malaria elimination. By contrast, in many parts of SEA, dengue cases have increased and the disease is endemic in many places (Figure 1B), with recent epidemics recorded in Cambodia, Indonesia, Malaysia, the Philippines, and Thailand [2].

The risk of both malaria and dengue depends intimately on the environment, with major land-use changes often increasing the risk of transmission [3]. Over the past 30 years there has been an unprecedented increase in **rubber plantations** in SEA as a consequence of the economic development in the region. Here we examine the potential threat posed by the growth of rubber plantations and suggest ways of protecting plantation workers from **mosquito-borne diseases**, focusing on **vector control**.

Expansion of Rubber Plantations

Monocultures of the rubber tree *Hevea brasiliensis* are hugely important commercial crops with plantations in SEA supplying more than 90% of the global demand for **natural rubber** (http://www.rubberstudy.com). The growth of the Chinese economy resulted in a high demand for rubber, with record high rubber prices, which lead to an expansion of rubber plantations. In 2010 SEA had 9.2 million ha of rubber plantations, with the largest plantations in Indonesia (2.9 million ha), Thailand (2.6 million ha), and Malaysia (1.1 million ha) (Figure 1C) (http://www.fao.org).

Trends

Rubber plantations in Southeast Asia (SEA) have been expanding at an unprecedented pace. It is estimated that 4.5–6 million people will be working on rubber plantations over the next decade, who are all at high risk of mosquito-borne diseases.

Many countries in SEA are focusing on malaria elimination. Rubber plantations may create barriers for elimination since they provide suitable habitats for vectors, a large migrant workforce, and high vector exposure risk.

Dengue is the most rapidly expanding disease in the world. Rubber plantations could assist this spread since plantations have high densities of *Aedes albopictus*, a dengue vector, and are close to the sylvatic cycle.

Investing in the health of rubber-plantation workers is financially beneficial to the rubber industry and should be a partnership between the health sector, rubber industry, and local communities.

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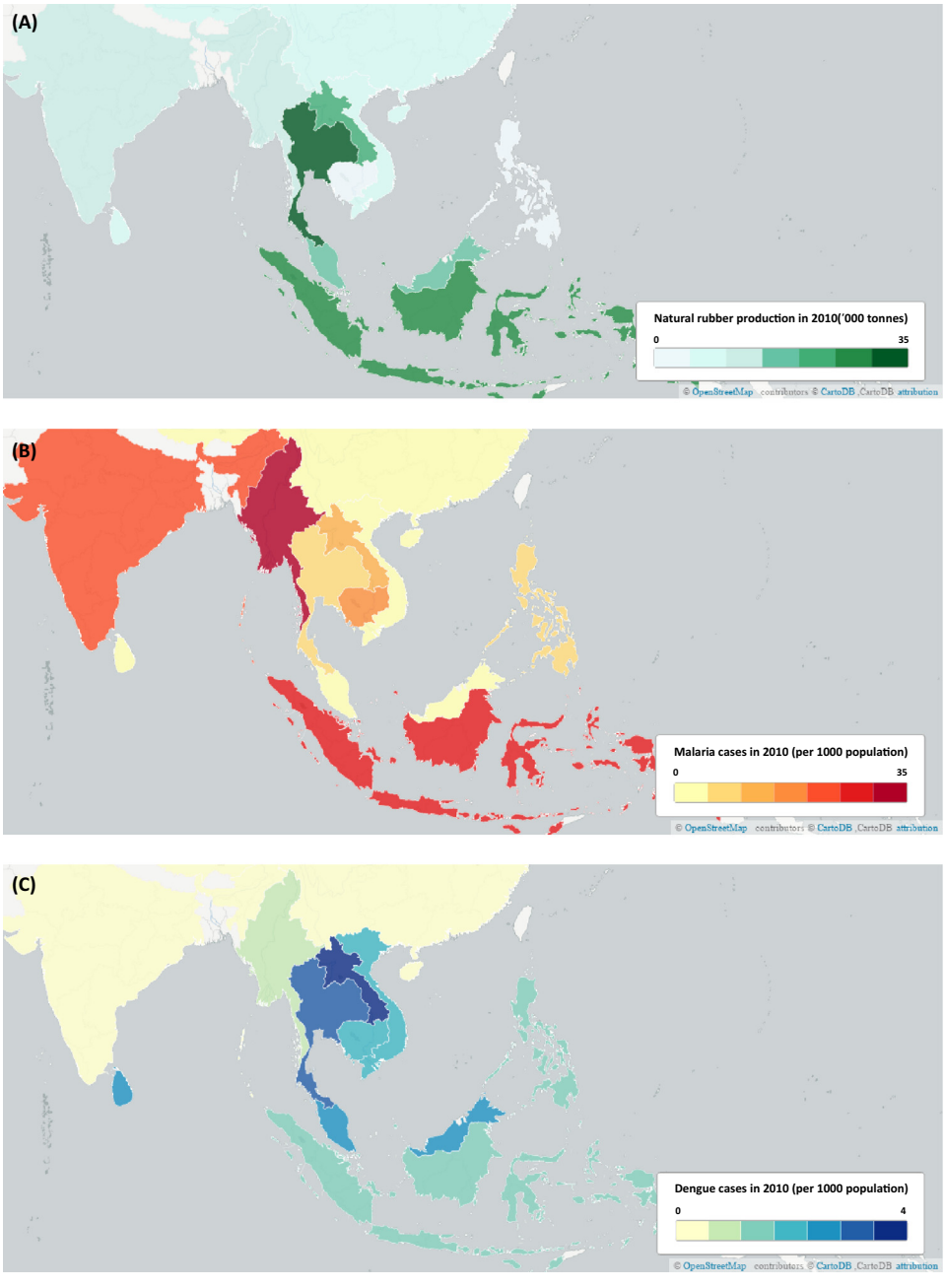

Figure 1. Disease Distribution Maps in Southeast Asia. (A) Rubber production in 2010. (B) Malaria cases in 2010. (C) Dengue cases in 2010. Data collected from [1] (http://www.anrpc.org; http://data.worldbank.org; http://www.searo.who.int). Images made using © CartoDB.

Although rubber prices have dropped (http://www.anrpc.org) since the onset of the 2008 global financial crisis when world industrial production contracted [4], it is anticipated that large acreages of rubber will continue to be cultivated across SEA in the future.

Rubber plantations are essentially manmade forests with generally higher humidity and lower temperatures under the canopy than non-tree crops, making them ideal environments

Glossary

Anthropophilic: vectors attracted to people.
Artemisinin-based combination therapy (ACT): recommended by the WHO for treatment of uncomplicated *falciparum* malaria.
Chikungunya: a disease caused by the chikungunya virus from the family *Togaviridae*, transmitted by the mosquitoes *Ae. albopictus* and *Aedes aegypti*.
Community protection using vector control: mosquito control using methods that reduce mosquito numbers in an area and/or the survival of the vector population, thus providing greater protection than can be achieved by deploying vector control at an individual level (vs individual protection).
Dengue: a febrile illness caused by the dengue virus from the family *Flaviviridae*, transmitted by *Ae. aegypti* and *Ae. albopictus*.
Emerging infectious diseases: a group of infectious diseases that have emerged, increased in incidence, or spread in geographical area.
Endophagic: having a tendency to blood feed indoors.
Exophagic: having a tendency to blood feed outdoors.
Exophilic: having a preference for resting outdoors.
Genetic control: controlling mosquitoes by releasing sterile males or genetically modified mosquitoes into an area.
Integrated vector management (IVM): adaptive, evidence-based vector management that draws on vector control measures from both within and outside the health sector.
Larval source management (LSM): management of immature mosquito life stages using environmental management, larvicides, and biological control.
Latex: a white, milky suspension of rubber polymers released from the *Hevea brasiliensis* tree after tissue injury.
Malaria: an infectious disease caused by parasitic protozoans of the genus *Plasmodium*, transmitted by *Anopheles* mosquitoes.
Mosquito-borne disease: transmission of pathogens from human and animals to humans and animals by a mosquito vector.