

## PLASMODIUM INFECTIONS IN ANOPHELES MOSQUITOES IN UBON RATCHATHANI PROVINCE, NORTHEASTERN THAILAND DURING A MALARIA OUTBREAK

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**ABSTRACT.** An unprecedented malaria outbreak occurred in Ubon Ratchathani Province, northeastern Thailand, in 2014. The province showed the highest number of malaria cases of all Thai provinces. Five entomological surveys were conducted at 8 sentinel sites from September 2013 to September 2015 to address the role of different *Anopheles* species in malaria transmission. Mosquito collections were conducted using human landing catches and cow bait. A total of 10,369 *Anopheles* mosquitoes were collected and 2,240 were morphologically identified as potential malaria vectors, including *An. dirus* ( $n = 78$ ), *An. minimus* ( $n = 18$ ), *An. sawadwongporni* ( $n = 4$ ), *An. barbirostris* s.l. ( $n = 819$ ), *An. philippinensis* ( $n = 612$ ), *An. nivipes* ( $n = 676$ ), *An. annularis* ( $n = 42$ ), *An. aconitus* ( $n = 7$ ), and *An. rampae* ( $n = 142$ ). Real-time polymerase chain reaction was used to screen for the presence of *Plasmodium* spp. in salivary glands. The proportion of primary vectors of surveyed villages was very low ( $<1\%$ ), and no *Plasmodium*-infected specimens were detected among in the 2,240 *Anopheles* mosquitoes tested. The absence of positive *Plasmodium* samples during malaria outbreaks suggests that malaria transmission most likely occurred outside the villages, particularly in the deep-forested hilly areas that provided suitable habitats for competent malaria vectors. These results emphasize the need to develop vector control related to village community activities to reduce malaria transmission along Thailand border areas.

**KEY WORDS** Epidemic, forest, national border, vector, village, transmission

### INTRODUCTION

Malaria in the Greater Mekong Subregion (GMS), which includes Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, Viet Nam, and the People's Republic of China (Yunnan Province and the Guangxi Zhuang Autonomous Region), poses a serious public health threat. Populations at most risk reside/work along international borders and in forested areas, e.g., local migrants, refugees, and forest workers (Corbel et al. 2013). Approximately 700 million people that are at risk, work/reside in the GMS, with 447,827 confirmed malaria cases and 342 deaths reported in 2013—most in Myanmar (WHO-WPRO 2015). The World Health Organization Strategy for Malaria Elimination program in the GMS (2015–2030) has set a goal for malaria elimination in all GMS countries by 2030 and *Plasmodium falciparum* (Welch) malaria by 2025 (WHO-WPRO 2015).

Thailand aims to eliminate malaria by 2024 (Ministry of Public Health 2016). Current malaria control measures used in the prevention of malaria transmission include insecticide-impregnated bed nets and indoor residual spraying. In Thailand, the proportion of *P. falciparum* and *P. vivax* (Grassi and Feletti) is approximately 40% and 60%, respectively (WHO 2015). Despite successful control programs and reductions in morbidity and mortality over the past decades, malaria continues to remain a serious health threat, especially along underdeveloped border areas (Suwonkerd et al. 2013).

Tak Province, located at the Thailand–Myanmar border, is usually responsible for the highest number of annual malaria cases (Parker et al. 2015, Songkong et al. 2015). Ubon Ratchathani Province, in northeastern Thailand, has never been in the top 10 provinces for malaria incidence. While the annual number of malaria cases in Ubon Ratchathani between 2003 and 2013 were similar, averaging 645 cases/year (Lyttleton 2016), a malaria outbreak occurred in 2014 (Fig. 1) (Lyttleton 2016), increasing from 1,130 in 2013 to 7,708 cases in 2014. This was a 7-fold increase and accounted for 26% of the total number of reported malaria cases in Thailand (Department of Disease Control 2017). The preponderance of malaria cases were reported from 6 districts: Buntharik, Nachaluay, Nam Yuen, Si Mueang Mai, Sirindhorn, and Det Udom (Department of Disease Control 2017). To identify the causes of resurgence of malaria cases in the GMS, a longitudinal survey was conducted from September 2013 to September 2015 in villages and other settings

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