Short Report: Mosquito Species Composition and *Plasmodium vivax* infection Rates for Korean Army Bases near the Demilitarized Zone in the Republic of Korea, 2011

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Abstract. Vivax malaria is a significant military and civilian health threat in northern Republic of Korea (ROK). Mosquito collections were performed at two ROK army installations, Paju near the demilitarized zone (DMZ) using black light traps in 2011. The DMZ, a 4 km wide border, is the northernmost point of the ROK and separates the ROK from the Democratic People's Republic of Korea (DPRK). *Anopheles* spp. were identified by polymerase chain reaction and screened for *Plasmodium vivax* sporozoites. Of 4,354 female *Anopheles* mosquitoes identified, *Anopheles kleini* (61.8%) was the most frequently collected, followed by *Anopheles pullus* (16.0%), *Anopheles belenrae* (9.0%), *Anopheles sinensis* (7.4%), *Anopheles sineroides* (4.2%), and *Anopheles lesteri* (1.6%). *Anopheles kleini*, *An. pullus*, and *An. sineroides* showed the highest population densities in June, whereas population densities were highest for *An. belenrae*, *An. lesteri*, and *An. sinensis* in August. The maximum likelihood estimation (estimated number of positive mosquitoes/1,000) for *P. vivax* was highest for *An. lesteri* (28.9), followed by *An. sineroides* (23.3), *An. belenrae* (15.8), *An. sinensis* (9.6), *An. pullus* (5.8) and *An. kleini* (4.2). The seasonal maximum likelihood estimation (MLE) values were variable among *Anopheles* species. *Anopheles belenrae*, *An. pullus*, and *An. sineroides* showed the highest seasonal MLE's in July, whereas *An. lesteri* and *An. sinensis* exhibited the highest seasonal MLEs in September and *An. kleini* during August. This is the first report implicating *An. sineroides* as a vector of *P. vivax* in the ROK, and extends our knowledge of the distribution and potential role in malaria transmission.

In the Republic of Korea (ROK, South Korea), *Plasmodium vivax* malaria has been endemic for centuries.^{1,2} In the 1960s and 1970s, active and passive vivax malaria case detection and vector control, which included extensive use of pesticides, were combined in an ambitious eradication project by the ROK government.¹ In the mid-1970s, indigenous transmission cases of malaria were greatly reduced and in 1979, the World Health Organization (WHO) declared the ROK as a malaria-free zone.^{3,4} *Plasmodium vivax* malaria reemerged when two cases were reported in northwestern Gyeonggi Province near the demilitarized zone (DMZ) in 1993.⁵ *Plasmodium vivax* malaria rapidly increased to a high of 4,142 cases by 2000, before declining to 864 cases by 2004.^{2,6–11} Malaria steadily increased to 2,227 cases by 2007, but decreased to 811 by 2011.¹¹

Although *Anopheles* spp. populations are high throughout the ROK, the primary malaria threat has remained in northern Gyeonggi Province near the DMZ where transmission rates are high.^{12–14} Reasons for the concentration of malaria along the DMZ are not well understood, although WHO reported that a malaria epidemic occurred in the Democratic People's Republic of Korea (DPRK, North Korea) shortly after the first case of malaria was reported in 1993 near the DMZ in the ROK, suggesting a parallel outbreak occurred in both countries.¹⁵ Unique conditions in the vicinity of the DMZ, such as the exposure of large numbers of soldiers to malaria parasites and the unmanaged nature of the environment that encourages mosquito breeding, are thought to exacerbate the malaria situation.^{3,16}

Of the total number of malaria cases in the ROK, over 40% have been reported among ROK military personnel deployed to Korean army installations located near the DMZ since 2001.¹⁷ The ROK army has managed malaria in high-risk areas by implementing a mass chemoprophylaxis program rather than vector control. To effectively monitor malaria risks, vector-borne disease surveillance is an essential component. A preliminary investigation to identify the seasonal population distributions of *Anopheles* spp. at two Korean army installations near the DMZ was conducted. High malaria sporozoite rates among multiple species within the perimeter of Korean army installations suggest that alternative preventative measures (i.e., vector control) may effectively reduce malaria risks.

Adult mosquitoes were collected outside barracks at two ROK army installations (37°54'33"N 126°42'40"E and 37°54'14"N 126°42'15"E), malaria high-risk areas near the DMZ using black light traps hung on the barrack walls (Yoshizawa type, black light FL-6w, Shinyoung Co., Seoul, Republic of Korea) weekly from April through October 2011 (Figure 1). The DMZ is 248 km long and 4 km wide, mined, and a heavily fortified zone that divides the Korean peninsula across the 38th parallel that serves as an armistice buffer zone between the ROK and the DPRK. The surrounding area within the DMZ, which is not under wetland rice, consists of forested hills and low-lying unmanaged grasslands (abandoned rice paddies since the end of the Korean War) that flood during rains. The installations are located southwest of Panmunjeom and the Joint Security Area (JSA). Panmunjeom and the JSA, where meetings are held between the ROK and the DPRK governments, are ≈6.3 km and ≈2.7 km from the ROK army installations, respectively. The installations were ≈0.3 km north from a station between the ROK and the DPRK and 2.0 km north from Tongilchon, a small farming village with ≈400 residents. Approximately

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FIGURE 1. The area surveyed in Paju, Gyeonggi Province, the Republic of Korea. The squares denote the collection sites.

500 soldiers are stationed at each installation, which is surrounded by rice paddies. Mosquito collections were conducted about 0.5 km between the two installations. Black light traps were set 1.5 m above the ground and mosquitoes were collected two times weekly from 18:00 PM to 07:00 AM. The collected mosquitoes were preserved in 100% ethanol and transferred to Korea Centers for Disease Control and Prevention (KCDC) for DNA extraction and species characterization.

Members of *Anopheles* mosquitoes were identified to species by polymerase chain reaction (PCR) with genomic

DNA extracted from single legs of individual adult mosquitoes as described by Wilkerson and others¹⁸ and Li and others.¹⁹ The PCR products were separated on a 2% agarose gel and visualized with Safe-pinky DNA Gel staining solution ($\times 10,000$) (GenDepot, Houston, TX). Fragment sizes were estimated by comparison to molecular weight standards provided by the 100-bp Ladder Molecular Weight DNA Marker (Bioneer, Seoul, ROK). After mosquitoes were identified to species, the anterior (head and thorax) were separated and pooled (1–10 specimens) and tested

TABLE 1
Primers and polymerase chain reaction (PCR) conditions for detection and identification of *Plasmodium vivax*

Step	Primer	Species	Sequence (5'→3')	Diagnostic bands			
1st PCR	rLU5	<i>Plasmodium falciparum</i>	CCT GTT GTT GCC TTA AAC TTC	1,100 bp			
	rLU6	<i>Plasmodium vivax</i> <i>Plasmodium malariae</i> <i>Plasmodium ovale</i>	TTA AAA TTG TTG CAG TTA AAA CG				
2nd PCR	rVIV1 rVIV2	<i>Plasmodium vivax</i>	CGC TTC TAG CTT AAT CCA CAT AAC TGA TAC ACT TCC AAG CCG AAG CAA AGA AAG TCC TTA	120 bp			
		Reagent	Volume				
Reaction mixture			1st PCR	2nd PCR			
	Customized PCR premix kit (Added each primer, Accupower. Bioneer)		—	—			
	DNA template (10 ng/μℓ)		3.0 μℓ	3.0 μℓ			
	3rd deionized distilled water		17.0 μℓ	17.0 μℓ			
		Total	20.0 μℓ				
		Temperature (°C)	Time (min)	Cycle			
		1st PCR	2nd PCR	1st PCR	2nd PCR		
PCR		94	92	5	5	1	1
		92	92	0.5	1/3	30	31
		60	58	1	1/3		
		72	72	1	1/3		
		72	72	5	5	1	1
		4	4	∞	∞	∞	∞

TABLE 2

Total number of mosquitoes collected with black light traps near two barracks at ROK army installations near on the DMZ, Paju, Gyeonggi Province, Republic of Korea, from May to October, 2011*

Species	Female (%)	Male	Total
<i>Anopheles</i> spp.	4,354 (86.6)	15	4,369
<i>Aedes vexans nipponii</i>	484 (9.6)	22	506
<i>Culex pipiens</i>	81 (1.6)	15	96
<i>Culex bitaeniorhynchus</i>	22 (0.4)	1	23
<i>Culex vagans</i>	21 (0.4)	1	22
<i>Aedes albopictus</i>	16 (0.3)	0	16
<i>Culex tritaeniorhynchus</i>	15 (0.3)	0	15
<i>Armigeres subalbatus</i>	10 (0.2)	0	10
<i>Aedes vexans nipponii</i>	9 (0.2)	0	9
<i>Aedes bekku</i>	4 (0.1)	0	4
<i>Culex orientalis</i>	3 (0.1)	0	3
<i>Mansonia uniformis</i>	2 (< 0.1)	0	2
<i>Ochlerotatus koreicus</i>	2 (< 0.1)	1	3
<i>Aedes lineatopennis</i>	1 (< 0.1)	0	1
<i>Culex rubens</i>	1 (< 0.1)	1	2
Total	5,025 (100.0)	56	5,081

*ROK = Republic of Korea; DMZ = demilitarized zone.

using PCR for genomic *P. vivax* DNA by single step and semi-nested multiplex-PCR (Table 1). Detection and identification of malaria species were simultaneously performed using a sequence of two (semi-nested) PCRs (Table 2),²⁰ and the sizes of the products estimated after electrophoresis on 2% agarose gels and staining with Safe-pinky DNA Gel staining solution ($\times 10,000$). A Custom Accupower Hotstart PCR premix (100 mM Tris, 15 mM MgCl₂, 400 mM KCl, 1 U Top polymerase, 1 U PPase, stabilizer, and 0.025 dye) (Bioneer, Daejeon, ROK) was used. Known positive and

negative samples from previous malaria positive and negative specimens were used as controls. Genomic DNA of *P. vivax* from blood of malaria patients was used for the known positive samples. Fragment sizes were estimated by comparison to molecular weight standards provided by 100-bp Ladder Molecular Weight DNA Marker (Bioneer).

A total of 5,025 female mosquitoes, *Anopheles* spp. (4,354) and culicines (671), composed of six genera and 15 species, were collected at two ROK army installations from May through October (Table 2). Overall, *Anopheles* spp. made up 86.6% of the collections, of which *Anopheles kleini* Rueda predominated (61.8%), followed by *Anopheles pullus* Yamada (16.0%), *Anopheles belenrae* Rueda (9.0%), *Anopheles sinensis* Wiedemann (7.4%), *Anopheles sineroides* (4.2%), and *Anopheles lesteri* Baisas and Hu (1.6%). No *Anopheles koreicus* Yamada and Watanabe, and *Anopheles lindesayi japonicus* Yamada were collected. The seasonal distribution of each of the *Anopheles* species was variable. Relatively low numbers of *Anopheles* mosquitoes were collected in May when trapping was initiated, sharply increased during June, but decreased during July. The reduction in population density during July may have resulted from heavy monsoon rains (1,093.1 mm), which accounted for over 50% of total rainfall (2,063.3 mm) during 2011 (Figure 2). *Anopheles* populations increased in August but sharply decreased in September and October caused by the onset of cooler temperatures. To effectively manage malaria in the ROK army, multi-year data on geospatial and seasonal distribution patterns of *Anopheles* mosquitoes are required. Rueda and others²¹ and Kim and others²² reported the monthly distribution of *Anopheles* species larvae at an

FIGURE 2. Mean temperature monthly high and low temperatures (°C), precipitation (mm), and number of *Anopheles* mosquitoes collected monthly.

TABLE 3

Total number of malaria-infected mosquitoes collected with black light traps near two barracks at ROK army installation near the DMZ, Paju, Gyeonggi Province, Republic of Korea, from May to October, 2011

Species	No. of <i>Anopheles</i> mosquitoes (MLE)*						Number identified (%)	Pools tested	Positive pools	MLE
	May	Jun	Jul	Aug	Sep	Oct				
<i>Anopheles lesteri</i>	0 (–)	7 (0.0)	21 (0.0)	37 (27.2)	5 (205.9)	0 (–)	70 (1.6)	21	2	28.9
<i>Anopheles sineroides</i>	17 (0.0)	76 (13.3)	43 (23.2)	40 (50.7)	5 (0.0)	0 (–)	181 (4.2)	37	4	23.3
<i>Anopheles belenrae</i>	9 (0.0)	58 (0.0)	32 (63.1)	197 (21.4)	94 (0.0)	4 (0.0)	394 (9.0)	59	6	15.8
<i>Anopheles sinensis</i>	1 (0.0)	3 (0.0)	24 (0.0)	248 (8.2)	44 (21.9)	2 (0.0)	322 (7.4)	49	3	9.6
<i>Anopheles pullus</i>	40 (0.0)	225 (0.0)	106 (9.5)	217 (9.4)	109 (8.8)	1 (0.0)	698 (16.0)	92	4	5.81
<i>Anopheles kleini</i>	15 (0.0)	1,061 (2.9)	965 (4.2)	625 (6.5)	21 (0.0)	2 (0.0)	2,689 (61.8)	286	11	4.16
Total	82 (0.0)	1,430 (2.8)	1,191 (6.9)	1,364 (11.4)	278 (10.8)	9 (0.0)	4,354	544	30	7.1

*MLE = the maximum likelihood estimations, (estimated number of positive mosquitoes/1,000).
ROK = Republic of Korea; DMZ = demilitarized zone.

adjacent study site that was similar to our data, which indicates the importance of multi-year data of mosquito collections based on remote sensing ecological measurements.

Of 544 pools of *Anopheles* mosquitoes, 30 pools (5.5%) were positive for *P. vivax* with an overall maximum likelihood estimation (estimated number of *P. vivax* DNA-positive mosquitoes per 1,000) of 7.1. The MLE was calculated using PooledInfRate (Biggerstaff, CDC, www.cdc.gov/ncidod/dvbid/westnile/software.htm). Previous reports have shown the annual MFIR [(number of positive pools/number of female mosquitoes) $\times$ 1,000] for flavivirus infections in mosquitoes,^{23–25} which estimates the lower bound of the infection rate, whereas MLE estimates infection rates itself.^{26,27} The MLE for each *Anopheles* spp. was highest for *An. lesteri* (28.9), followed by *An. sineroides* (23.3), *An. belenrae* (15.8), *An. sinensis* (9.6), *An. pullus* (5.8), and *An. kleini* (4.2). Although *An. lesteri* showed the highest MLE, population densities were very low.²⁸ However, in other areas of the northwestern part of the ROK, higher population densities of *An. lesteri* are reported.²⁹ The MLE of *An. kleini* was the lowest among six of the *Anopheles* species, despite a high number of *P. vivax* DNA-positive pools. The reason for this is that *An. kleini* showed higher population densities compared with other *Anopheles* species. Preliminary data also suggests that *An. kleini* may be a principal vector of *P. vivax* malaria near the DMZ,¹⁰ as laboratory studies found that *An. kleini* produced many sporozoites.²⁹ Seasonal MLE's of *Anopheles* mosquitoes increased from June to September. All six species of *Anopheles* collected were positive for *P. vivax*, and this is the first report of vivax-positive *An. sineroides* in the ROK, which also showed high MLE values from June to August. The MLE for *An. belenrae* (63.1) and *An. pullus* (9.5) were the highest in July, highest for *An. kleini* (6.5) and *An. sineroides* (50.7) in August, and highest for *An. lesteri* (205.9) and *An. sinensis* (21.9) in September (Table 3).

Vector control as part of an effective malaria management program in the ROK army requires a better understanding of vector species distribution, population densities, anthropophilic behavior of vector species, malaria infection rates, in addition to vector potential. Six *Anopheles* mosquito species of the Hyrcanus group in the ROK are potential vectors of *P. vivax*. However, primary vector mosquito species are affected by their geospatial and seasonal distribution, in addition to other factors relating to human attraction and exposure. Data that provides accurate ecological factors of potential vector populations in areas where human exposure is greatest is needed. Furthermore, KCDC

assets, i.e., Korea National Institutes of Health (KNIH) and Quarantine stations, must be augmented, when possible, with the United States preventive medicine assets, i.e., Medical Detachments, universities, and the Armed Forces Health Surveillance Center, to provide more timely and accurate analysis of information and effective protection for Korean military and civilians near the DMZ. These data provide the Korean army and civilians near the DMZ with a more precise disease risk analysis, in addition to recommendations for instituting effective vector control and disease reduction strategies.

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REFERENCES

1. Paik YK, Ree HI, Shim JC, 1988. Malaria in Korea. *Jpn J Exp Med* 58: 55–66.
2. Jun G, Yeom JS, Hong JY, Shin EH, Chang KS, Yu JR, Oh SO, Park JW, 2009. Resurgence of *Plasmodium vivax* malaria in the Republic of Korea during 2006–2007. *Am J Trop Med Hyg* 81: 605–610.
3. Ree HI, 2000. Unstable vivax malaria in Korea. *Korean J Parasitol* 38: 119–138.
4. World Health Organization, 1981. Synopsis of the world malaria situation in 1979. *Wkly Epidemiol Rec* 56: 145–149.
5. Chai IH, Lim GI, Yoon SN, Oh WI, Kim SJ, Chai JY, 1994. Occurrence of tertian malaria in a male patient who has never been abroad. *Korean J Parasitol* 32: 195–200.
6. Chai JY, 1999. Re-emerging *Plasmodium vivax* malaria in the Republic of Korea. *Korean J Parasitol* 32: 195–200.

7. Cho SY, Kong Y, Park SM, Lee JS, Lim YA, Chae SL, Kho WG, Lee JS, Shim JC, Shin HK, 1994. Two vivax malaria cases detected in Korea. *Korean J Parasitol* 32: 281–284.
8. Korea-National Institute of Health, 2001. *Manual for Malaria Control*. Seoul, Korea: Korea-National Institute of Health.
9. Korea-Center for Disease Control and Prevention, 2005. Provisional cases of selected notifiable disease. *K-CDC Commun Dis Wkly Rep* 53: 1–32 (CDWR).
10. Lee WJ, Klein TA, Kim HC, Choi YM, Yoon SH, Chang KS, Chong ST, Lee IY, Jones JW, Jacobs JS, Sattabongkot J, Park JS, 2007. *Anopheles kleini*, *Anopheles pullus*, and *Anopheles sinensis*: potential vectors of *Plasmodium vivax* in the Republic of Korea. *J Med Entomol* 44: 1086–1090.
11. Korea Centers for Disease Control and Prevention (K-CDC), 2011. *Disease Web Statistics System*. Available at: <http://cdc.go.kr/kcdchome/jsp/observation/stat/rgt/STATRGT0003List.jsp>. Accessed January 19, 2011.
12. Lee JS, Kho WG, Lee HW, Seo M, Lee WJ, 1998. Current status of vivax malaria among civilians in Korea. *Korean J Parasitol* 36: 241–248.
13. Lee HI, Lee JS, Shin EH, Lee WJ, Kim YY, Lee KR, 2001. Malaria transmission potential by *Anopheles sinensis* in the Republic of Korea. *Korean J Parasitol* 39: 185–192.
14. Kim HC, Pacha LA, Lee WJ, Lee JK, Gaydos JC, Sames WJ, Lee HC, Bradley K, Jeung GG, Tobler SK, Klein TA, 2009. Malaria in the Republic of Korea, 1993–2007. Variables related to re-emergence and persistence of *Plasmodium vivax* among Korean populations and U.S. Forces in Korea. *Mil Med* 174: 762–769.
15. Han ET, Lee DH, Park KD, Seok WS, Kim YS, Tsuboi T, Shin EH, Chai JY, 2006. Reemerging vivax malaria: changing patterns of annual incidence and control programs in the Republic of Korea. *Korean J Parasitol* 44: 285–294.
16. Klein TA, Pacha LA, Lee HC, Kim HC, Lee WJ, Lee JK, Jeung GG, Sames WJ, Gaydos JC, 2009. *Plasmodium vivax* malaria among U.S. Forces Korea in the Republic of Korea. *Mil Med* 174: 412–418.
17. KCDC, 2011. *A Guideline of Malaria Management*. Republic of Korea: Korea Center for Disease Control and Prevention.
18. Wilkerson RC, Li C, Rueda LM, Kim HC, Klein TA, Song GH, Strickman D, 2003. Molecular confirmation of *Anopheles (Anopheles) lesteri* from the Republic of South Korea and its genetic identity with *An. (Ano.) anthropophagus* from China (Diptera: Culicidae). *Zootaxa* 378: 1–14.
19. Li C, Lee JS, Groebner JL, Kim HC, Klein TA, O'Guinn ML, Wilkerson RC, 2005. A newly recognized species in the *Anopheles hyrcanus* group and molecular identification of related species from the Republic of (South) Korea (Diptera: Culicidae). *Zootaxa* 939: 1–8.
20. Snounou G, Viriyakosol S, Zhu XP, Jarra W, Pinheiro L, do Rosario VE, Thaithong S, Brown KN, 1993. High sensitivity of detection of human malaria parasites by nested polymerase chain reaction. *Mol Biochem Parasitol* 61: 315–320.
21. Rueda LM, Brown TL, Kim HC, Chong ST, Klein TA, Foley DH, Anyamba A, Smith M, Pak EP, Wilkerson RC, 2010. Species composition, larval habitats, seasonal occurrence and distribution of potential malaria vectors and associated species of *Anopheles* (Diptera: Culicidae) from the Republic of Korea. *Malar J* 9: 55.
22. Kim HC, Rueda LM, Wilkerson RC, Foley DH, Sames WJ, Chong ST, Nunn PV, Klein TA, 2011. Distribution and larval habitats of *Anopheles* species in northern Gyeonggi Province, Republic of Korea. *J Vector Ecol* 36: 124–134.
23. In SD, Shim JC, Lee MH, Paik SB, 1985. Ecological study of Japanese encephalitis virus in Korea (1) Report on the JE virus isolated from mosquitoes. *Rep Nat Inst Health Korea* 22: 229–239.
24. In SD, Shim JC, Choi JH, Kim JI, Lee IB, Yong KH, 1986. Epidemiological study on Japanese encephalitis in Korea. *Rep Nat Inst Health Korea* 23: 377–389.
25. Turell MJ, O'Guinn ML, Wasieleski LP, Dohm DJ, Lee WJ, Cho HW, Kim HC, Burkett DA, Mores CN, Coleman RE, Klein TA, 2003. Isolation of Japanese encephalitis and Getah viruses from mosquitoes (Diptera: Culicidae) collected near Camp Greaves, Gyeonggi Province, Republic of Korea, 2000. *J Med Entomol* 40: 580–584.
26. Gu W, Lampman R, Novak RJ, 2003. Problems in estimating mosquito infection rates using minimum infection rate. *J Med Entomol* 40: 595–596.
27. Gu W, Lampman R, Novak RJ, 2004. Assessment of arbovirus vector infection rates using variable size pooling. *Med Vet Entomol* 18: 200–204.
28. Rueda LM, Li C, Kim HC, Klein TA, Foley DH, Wilkerson RC, 2010. *Anopheles belenrae*, a potential vector of *Plasmodium vivax* in the Republic of Korea. *J Am Mosq Control Assoc* 26: 430–432.
29. Joshi D, Choochote W, Park MH, Kim JY, Kim TS, Suwonkerd W, Min GS, 2009. The susceptibility of *Anopheles lesteri* to infection with Korean strain of *Plasmodium vivax*. *Malar J* 8: 42.