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Collection of Adult and Larval Mosquitoes in U.S. Army Compounds in the Republic of Korea During 1979~1983

Kwan Woo Lee, Raj K. Gupta and John A. Wildie
Entomology Section, 5th Preventive Medicine Unit, U.S. Army, Seoul, Korea

INTRODUCTION

The first mosquito collections in U.S. Army areas were conducted by Frommer of 5th Preventive Medicine Unit (PMU) from 1974 to 1977. The more intensive surveillance programs including larval habitat survey were continued in the areas from 1979~1983 applying the standard army regulation on mosquito surveillance program (Army TM 5-632 p.7-3).

Substantial amounts of mosquito adult and larva collection data have been accumulated between 1979~1983. The purpose of this paper is to present additional scientific data that will increase the current knowledge of the distribution, seasonal and geographical, of some mosquito species occurring in the U.S. Army compounds in Korea. The distribution of mosquitoes throughout Korea, especially vector species, is of great importance to the U.S. government as the military expends substantial amounts of manpower and chemical to control mosquitoes that present a health hazard to U.S. military personnel. The primary chemical used by the military to control mosquitoes is malathion. Shim *et al.* (1982) reported that the larvae of *Culex tritaeniorhynchus* showed resistance to malathion. His study creates some interesting questions for the military pest controllers. Yu *et al.* (1977 & 1979) have provided valuable data on some biological agents used to control larvae. Most mosquito breeding occurs off the military installation and the use of biological agents to control larvae is limited. Therefore, the development of an effective means of controlling adult mosquito will be needed.

The 5th PMU, from this collection, has developed an "index" level of female mosquitoes in a light trap similar to other U.S. Army Agencies in other parts of the world. When 10 female mosquitoes are reached on two consecutive trap night, or 5 known vector females such as *Culex tritaeniorhynchus* and *Anopheles sinensis* are collected, fogging is recommended in the trap areas.

MATERIALS AND METHODS

The distribution and abundance data presented in this paper were obtained from mosquitoes collected from U.S. Military Installations throughout the Republic of Korea using New Jersey light traps. The traps were operated on 12 military installations (Fig. 1) located in 5 Korean Provinces by local Area Facilities Engineer (AFE) pest control personnel. Collections were sent to the 5th PMU, Entomology Section for identification. In selecting a light trap location, other interfering lights within 100 yards of the trap sight were considered to avoid and the sites selected were located around 25~50 yards away from high buildings. The measurement from the light bulb of the trap to the ground surface was 6 feet, and a 25 watt, white frosted light bulb was used for the collections.

Thirty-nine (39) light traps were operated from 2 to 3 nights a week between 15 May to 15 October. The most abundant mosquitoes collected were those that breed primarily in rice

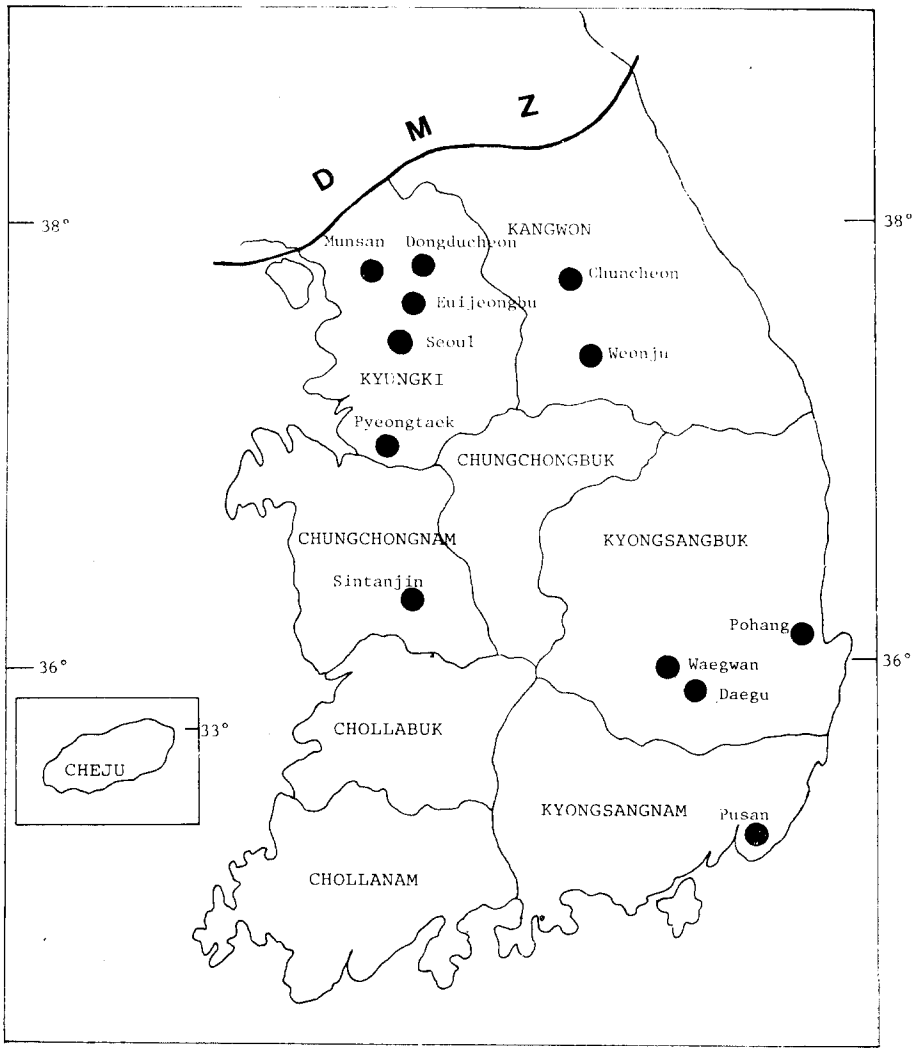

Fig. 1. Distribution of light-traps throughout the provinces for mosquito collection (1979~1980)

fields, ground pools, sewage and drainage ditches, culverts, and irrigation ponds located mainly off the Army installations. These mosquito breeding sites surveyed in the Army installations rarely occur except the rainy season.

Larval habitats were searched by the 5th PMU personnel with larval collecting dippers during the mosquito season. A sufficient number of larvae were caught to confirm only but not be counted in number by standard method of man-hour or man-dipper.

Light trap indices reported in this paper represent the average number of female mosquitoes collected per trap per night. Negative results were not always reported when samples were sent for identification. The monthly trap indices are reported only to provide the reader an indication of the relative abundance of female mosquitoes occurring in that area during a specific month. These indicies should not be erroneously interpreted as a true representation of the mosquito activity in the areas sampled.

RESULTS AND DISCUSSION

Average total of 10,888 female mosquitoes were

collected during 897 average trap nights over a 2-year period (1979~1980) using 39 New Jersey light traps. Seventeen mosquito species comprising 3 genera werecollected and identified. As shown in Table 1, the most abundant and widely distributed species were *Anopheles sinensis*, *Culex tritaeniorhynchus*, *Aedes vexans nipponii* and *Culex pipiens pallens*. All of these mosquitoes were collected from each installation as shown in Table 2.

A. sinensis was the most abundant species collected composing 40.2% and the next was *C. tritaeniorhynchus* composing 31% of the mosquitoes identified. *A. sinensis* is widely distributed over the Republic of Korea. However, the majority of the specimens collected were from Kyungki-do, particularly from the Pyeongtaek area. This mosquito is often found associated with *C. tritaeniorhynchus* breeding in such habitats as ground pools on U.S. Army installations, and rice fields, marshes and ground pools off the installations. This species sporadically occurred in collection samples in May. However, June is when this mosquito usually made its appearance and started to be collected in increasing numbers. *A. sinensis* populations normally peaked during July and declined in August when *C. tritaeniorhynchus* populations increased. Althouth *A. sinensis* levels decreased in August, it still remained the second most abundant species.

C. tritaeniorhynchus appeared first in collection during May. It reached its peak population levels in August then declined in September. This mosquito is considered to be the only kind of vector of Japanese encephalitis in Korea.

A. vexans nipponii comprised 19% of the specimens collected. In Korea, this mosquito is found breeding in ground pools and ponds with *A. sinensis* or *C. tritaeniorhynchus*. This species, although widely distributed throughout Korea, was collected primarily in the northern part of the ROK. It usually appeared in May and increased its population levels in June then declined in September. This mosquito often appeared to have multiple population peaks during July and August, but of lower magnitude than that observed in June.

C. pipiens pallens widely distributed and frequently collected, it comprised only 10% of the specimens identified. This species breeds in the open water habitats, where the water tends to

Table 1. Geographical distribution of mosquito species collected in U.S. Army Camp areas using New Jersey light traps and their relative abundance, 1979~1980

Mosquito species	Dongducheon	Eujeongbu	Munsan	Pyeongtaek	Yongsan	Wonju	Chuncheon	Shintanjin	Daegu	Pohang	Waegwan	Busan	Abundance (%)
Anopheles sinensis	×	×	×	×	×	×	×	×	×	×	×	×	40.2
A. sineroides	×	×	—	×	×	×	×	×	—	—	—	—	—
A. pullus	—	—	×	—	—	—	—	—	—	—	—	—	—
A. lesteri	—	—	—	×	—	—	—	—	—	—	—	—	—
A. lindesyi japonicus	—	—	—	—	—	—	—	—	×	—	—	—	—
A. koreicus	×	—	—	—	—	—	—	—	—	—	—	—	—
Aedes vexans nipponi	×	×	×	×	×	×	×	×	×	×	×	×	19.0
A. lineatopennis	—	—	×	—	—	—	—	—	—	—	—	—	—
Culex pipiens pallens	×	×	×	×	×	×	×	×	×	×	×	×	10.0
C. vagans	×	×	×	×	×	×	×	×	×	×	×	×	2.7
C. tritaeniorhynchus	×	×	×	×	×	×	×	×	×	×	×	×	31.0
C. orientalis	×	×	×	×	—	×	×	×	×	×	×	×	—
C. mimeticus	—	—	—	—	—	—	—	×	—	—	—	—	—
C. bitaeniorhynchus	×	—	×	×	×	—	×	—	—	—	—	—	—
C. rubensis	—	×	—	—	—	—	—	—	—	—	—	—	—

Table 2. Average number of adult female mosquitoes collected in U.S. Army Camp areas using New Jersey light traps, 1979~1980

Mosquito species by Area	Month						
	May	June	July	August	September	October	Total(%)
DONGDUCHEON, EUIJEONGBU, MUNSAN, PYEONGTAEK & YONGSAN (KYUNGKI DO)							
Anopheles sinensis	1	510	1,725	1,063	366	2	3,667(42)
A. sineroides	—	19	12	5	3	—	39
A. pullus	—	—	—	—	1	1	2
A. lesteri	—	—	—	2	—	—	2
A. koreicus	—	—	—	1	—	—	1
Aedes vexans nipponii	23	1,570	313	214	229	1	2,350(27)
A. lineatopennis	—	—	—	—	3	—	3
Culex pipiens pallens	12	180	298	229	160	6	885(10)
C. vagans	24	207	31	1	—	—	263 (3)
C. tritaeniorhynchus	—	6	392	958	195	5	1,556(18)
C. orientalis	2	4	8	13	5	—	32
C. bitaeniorhynchus	—	—	—	1	—	—	1
Total	62	2,496	2,779	3,487	962	15	8,801
Average Trap Night	32	140	142	157	132	34	637
Trap Index	2	18	20	16	7	0.4	14
WONJU AND CHUNCHEON (KANGWON DO)							
Anopheles sinensis	2	44	216	136	13	—	411(64)
A. sineroides	1	1	1	1	—	—	4
Aedes vexans nipponii	2	50	24	18	3	—	97(15)
Culex pipiens pallens	—	8	13	19	38	—	78(12)
C. vagans	—	3	—	—	—	—	3
C. tritaeniorhynchus	—	—	7	25	16	—	48(7)
C. orientalis	—	1	—	2	1	—	4
Total	5	107	261	201	71	—	645
Average Trap Night	2	11	14	14	11	—	52
Trap Index	3	10	19	14	6	—	12
HOIDUK (NEAR SHINTANJIN) (CHUNGCHONG NAM DO)							
Anopheles sinensis	2	110	320	33	39	2	506(50)
A. sineroides	—	12	1	3	1	—	17
A. lindesyii japonicus	—	—	—	—	—	1	1
Aedes vexans nipponii	49	184	55	6	1	—	295(29)
Culex pipiens pallens	—	6	13	3	15	—	37 (4)
C. vagans	7	18	1	1	—	—	27
C. tritaeniorhynchus	—	—	15	28	73	—	116(12)
C. orientalis	—	—	5	—	1	—	6
C. mimeticus	—	—	—	—	—	1	1
C. bitaeniorhynchus	—	—	—	—	—	1	1
Total	58	330	410	74	130	5	1,007
Average Trap Night	8	16	19	17	13	1	74
Trap Index	7	21	22	4	10	5	14

DAEGU, POHANG & WAEKWAN (KYUNGSANG BUK DO)							
Anopheles sinensis	—	10	113	21	4	—	148(44)
Aedes vexans nipponii	—	6	11	—	—	—	17 (5)
Culex pipiens pallens	—	17	28	12	7	—	64(19)
C. vagans	—	3	—	—	—	—	3
C. tritaeniorhynchus	—	—	18	57	26	—	101(30)
C. rubensis	—	1	—	—	—	—	1
Total	—	37	170	90	37	—	334
Average Trap Night	—	18	40	29	15	—	102
Trap Index	—	2	4	3	3	—	3
BUSAN (KYUNGSANG NAM DO)							
Anopheles sinensis	—	—	—	1	—	—	1
Culex pipiens pallens	—	1	3	1	4	—	9 (9)
C. vagans	—	1	—	—	—	—	1
C. tritaeniorhynchus	—	1	19	34	36	—	90(89)
C. orientalis	—	—	—	1	—	—	1
Total	—	3	21	37	40	—	101
Average Trap Night	—	6	10	9	7	—	32
Trap Index	—	1	2	4	6	—	3

be more stagnant with a higher organic content such as sewage ditches.

Anopheles lesteri was collected in very low numbers during this survey. The number of this specimens identified may be incorrect as *A. lesteri* is morphologically and taxonomically very similar to *A. sinensis* and is often counted in number of *A. sinensis*. Future collections of *A. siensis* from every locations will be more intensively checked for *A. lesteri*. Until the characteristics separating these species are more clearly defined and the taxonomic position of *A. listeri*

Table 3. Mosquito larval habitats surveyed in U.S. Army Installations, 1979~1983

Habitat	*Anopheles sinensis*	*A. sineroides*	*Aedes vexans nipponii*	*A. alboscutellatus*	*A. albopictus*	*A. chemulpoensis*	*A. koreicus*	*A. togoi*	*A. japonicus*	*A. hatorii*	*Culex pipiens pallens*	*C. orientalis*	*C. vagans*	*C. tritaeniorhynchus*	*Armigeres subalbatus*
Artificial container	×	—	×	—	—	—	×	—	—	—	×	—	×	×	—
Car track on road	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
Drainage ditches	×	—	×	—	—	—	—	—	—	—	×	×	×	—	—
Fire water barrel	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—
Ground pool	×	—	×	×	—	—	—	—	—	—	×	×	×	×	—
Marsh	—	—	—	—	—	—	—	—	—	—	×	—	×	—	—
Old tire	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—
Pond	×	—	—	—	—	—	—	—	—	—	×	—	×	—	—
Rice paddy	×	—	×	—	—	—	—	—	—	—	×	×	×	—	—
Rock hole and cavity	—	—	—	—	—	—	×	—	×	×	×	×	—	×	×
Sewage pool	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—
Sement tank	×	—	—	—	—	—	—	—	—	—	×	×	—	—	—
Stagnant water	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stream	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—
Swamp	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—
Tree hole	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—

is better understood, the correct distribution and abundance of *A. lesteri* in Korea will not be accurately known.

Culex vagans was widely distributed and frequently collected from early May to June, and it comprised only 2.7% of the specimens identified. Adults are known to attack man at night. Larvae occur usually in natural fresh water ground pools, occasionally invading turbid water pools associated with human dwelling areas (Hsiao and Bohart, 1946).

The remaining species were only collected in low numbers. All of these species are considered to be nuisance pests only and have not been associated with any mosquito-borne diseases in Korea.

According to the light trap and larval collection data, the most important mosquitoes occurring in the U.S. Army Installations were 4 species representing 3 genera, 1) *Anopheles sinensis*, 2) *Culex tritaeniorhynchus*, 3) *Aedes vexans nipponii* 4) *Culex pipiens pallens*. Larval habitats searched in the U.S.Army areas were categorized in 16 types as shown in Table 3. The larvae collected from the habitats were identified to be 15 species representing 4 genera.

SUMMARY

This paper is the result of adult female mosquito and larval collection in U.S. Army Installations in Korea from 1979 to 1983. New Jersey light traps were operated for adult collection from May to October.

The primary concern of this surveillance is to determine when to recommend insecticide spraying for mosquito control in the Army areas. The 5th Preventive Medicine Unit have developed an "index" level of female mosquitoes in a light trap similar to other U.S. Army Agencies in other parts of the world. When 10 female mosquitoes are reached on two consecutive trap-night, or 5 known vector females are collected, fogging is recommended in the trap areas.

1. Mosquito collections were conducted in 12 U.S. Army areas by operating 39 New Jersey light traps. Mosquitoes collected from the areas were identified to be 17 species comprising 3 genera. *Anopheles sinensis* (40%), *Culex tritaeniorhynchus* (31%), *Aedes vexans nipponii* (19%) and *Culex pipiens pallens* (10%) appeared to be the most common species in the areas.

2. The species, population density and monthly appearance of adult mosquitoes were found to be almost the same in the all provinces involved. And Japanese Encephalitis vector mosquitoes, *Culex tritaeniorhynchus*, showed their seasonal fluctuation from July to September with a peak in August each year.

3. Larval habitats confirmed in the Army areas were categorized into 16 types as shown in Table 3. The mosquito larvae collected in those habitats were identified to be 15 species representing 4 genera. Most breeding sites in the Army areas were those which are activated during the wet season.

4. More mosquitoes were collected from the Kyungki Province than from the other Provinces. The reason for more collection of mosquitoes from military installations in the Kyungki Province appears to be the geographic characteristics surrounded by rice fields, marshes and other stagnant water areas.

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=國文抄錄=

韓國에 駐屯한 美軍地域內에서의 모기 成蟲과 幼蟲 採集(1979~1983)

Entomology Section, 5th Preventive Medicine Unit, U.S. Army, Seoul, Korea
李冠雨 · R.K. Gupta · J.A. Wildie

本 論文은 1979~1983年에 걸쳐 韓國內에 駐屯하고 있는 美軍地域에서 5月부터 10月間 誘蚊燈(New Jersey)에 依한 모기 成蟲 採集과 그리고 幼蟲 採集을 實施한 것이다. 成蟲 採集數는 年平均置로 나타냈으며 誘蚊燈當 1日 採集數를 表示하여 美軍領內에 出現하는 모기 種과 出現時期 및 그 密度를 파악하여 모기 驅除對策을 강구하는데에 基本資料로 이용하였다.

모기 驅除를 爲한 殺蟲劑의 살포 基準은 雌蟲의 採集數가 2回 계속 10마리를 超過하거나 媒介體로 알려진 雌蟲이 5마리 以上 採集될 때 그 주변에 살포作業을 實施하도록 建議하였다(美陸軍規定 TM 5-632 p.7-3參考).

1. 모기 採集을 實施한 地域은 5個道內의 12個地域으로 39個의 誘蚊燈이 設置되었으며 이들 地域에서 採集된 모기種은 3屬 17種으로 分類되었으며, 그중 個體群의 密度가 높아 驅除對象으로 생각되는 種은 다음의 3屬 4種으로 나타났다. 1) *Anopheles sinensis* (40.2%), 2) *Culex tritaeniorhynchus* (31%), 3) *Aedes vexans nipponii*(19%), 4) *Culex pipiens pallens* (10%).

2. 誘蚊燈 設置地域은 京畿道內 5個地域, 江原道 2個地域, 忠南 1個地域 慶北 3個地域 慶南1個地域으로 이들 地域에서 採集된 重要 모기種은 共通的으로 같은 種類였으며 出現時期도 대체로 一置하였다. 特히 每年 社會的으로 問題가 되는 腦炎媒介種인 *Culex tritaeniorhynchus*는 出現時期가 7~9月間이었으며 그중 8月이 絕頂期로 나타났다.

3. 美軍駐屯地域에서 調査된 幼蟲棲息地는 16個 型態로 區分되었으며 그곳에서 採集된 幼蟲은 4屬 15種으로 分類되었다. 確認된 幼蟲棲息處는 一般的으로 雨期에 存在하는 一時的인 場所가 많았다.

4. 京畿道 地域에서 가장 많은 種과 높은 採集率을 보인 것은 誘蚊燈設置場所가 주로 논과 接해 있는 農村地域內에 속해 있기 때문으로 생각된다.