韓國環境衛生學會誌
Kor. J. Env. Hlth. Soc.
Vol.10, No.1, 55~65, 1984

Distribution and Abundance of Adult Female Mosquitoes Collected Using New Jersey Light Traps in the Republic of Korea, 1981—1982

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誘蚊燈 採集에 依한 모기 雌蟲의 個體群 密度와 分布(1981—1982)

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요 약

韓國內 9個道別 地域 가운데 5個道의 駐韓美軍事地域에서 39個의 誘蚊燈에 依하여 2,114 Trap night를 稼動하여 2년동안 採集하여 얻은 結果는 다음과 같다.

1. 3屬, 14種, 65,847마리의 암모기가 收集되었으며 금빛 숲모기, 중국 얼룩날개 모기, 빨간 집모기, 작은 빨간 집모기가 가장 넓게 分布되어 主種을 이루었다.

2. 작은 빨간 집모기(*Culex tritaeniorhynchus*)가 收集된 전체 암모기의 55.4%를 차지하였으며 5個道 全域에 걸쳐 分布되었으나 90% 以上이 평택지역에서 收集되었다. 이 種은 7月부터 收集되기 시작하여 8月에 가장 높은 個體群 密度를 나타내고 9月부터 減少한다. 1982년 採集된 모기數는 1981년 모기數의 5배에 達했다.

3. 중국 얼룩 날개 모기(*Anopheles sinensis*)는 收集된 전체 암모기數의 28.2%를 나타냈고 5月부터 散發的으로 나타나서 7, 8月에 높은 個體群 密度를 보이고 9月부터 減少한다. 1981년과 1982년의 採集된 모기數는 큰 差異를 나타내지 않았다.

4. 금빛 숲모기(*Aedes vexans nipponii*)는 收集된 전체 암모기數의 8.8%를 나타냈고 5개道 全域이 걸쳐 發生하나 主로 北쪽 地方에서 收集되었다. 이 種은 5月부터 나타나서 6月에 가장 높은 個體群 密度를 보이고 그후부터 減少하는 경향을 보이나 8月에 다시 조금 높은 發生을 나타내나 6月의 그것에 比하여 낮다.

5. 빨간 집모기(*Culex pipiens pallens*)는 전체 암모기數의 5.3%를 차지하였고 5個道 全域과 여름에 걸쳐 고루 分布되었다.

6. *Anopheles lesteri*는 평택지역에서 네마리가 採集되었으나 이 種은 중국 얼룩 날개 모기와 形態學的인 區分이 어려워서 더욱 면밀한 考察이 필요되어지며 나머지 9種의 모기는 매우 적은 數가 採集되었다.

7. 殺蟲劑와 모기 驅除法에 관하여 간략하게 논의되었다.

I. INTRODUCTION

This paper is a summarized report of adult female mosquitoes collected throughout the U.S. Army Installations in Korea using New Jersey Light Traps. The mosquitoes were collected by US Army Facilities Engineer pest control personnel operating the light traps during the mosquito breeding season, May through October, from 1981 through 1982.

Substantial amounts of mosquito collection data have been accumulated between 1981 and 1982. 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 Republic of Korea. The distribution of mosquito species throughout the Republic, especially vector species, is of great importance to US government as military expends substantial amounts of man-power and chemical to control mosquitoes that present a health harzard 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*, the reported vector of Japanese encephalitis, was resistant to malathion. Shim's study creates some interesting questions for the military pest controllers. The most important question that needs to be answered is "Just how effective is the malathion used in controlling the adult mosquitoes on US military installations throughout Korea?" The next logical question would be, "What alternatives to malathion do we have to control adult female mosquitoes?"

II. MATERIALS AND METHODS

The distribution and abundance data presented in this paper was obtained from mosquitoes collected from US military installations throughout the Republic of Korea using New Jersey Light Traps. The traps were operated on 18 military installations located in 5 Korean provinces (Figure 1) by local Area Facilities Engineer pest control personnel and sent to the 5th Preventive Medicine Unit, Entomology Services section for identification. A portion of dicholorovos impregnated was placed in the light trap collection jar to kill the mosquitoes.

Thirty-nine light traps were operated from 2

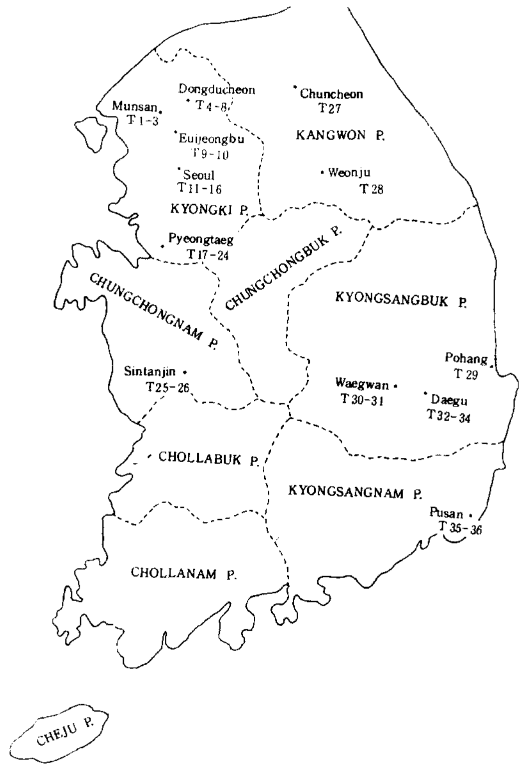

Fig. 1. Distribution of Light Trap Location Throughout the Province for Mosquito Collection.

to 3 nights a week between 15 May to 15 October. The majority of the mosquitoes collected between 1981-1982 apparently originated from breeding sites located off the military installations.

The most abundant mosquito species collected were those that breed primarily in rice fields, ground pools, sewage and drainage ditches, culverts, and irrigation ponds. These mosquitoes breeding sites rarely occur on US military installations.

Light trap indices reported in this paper

Table 1. Geographical Distribution of Mosquito Species Colleted Throughout Korea Using New Jersey Light Traps and Their Relative Abundance, 1981 – 1982

Species	CHUNGCHONGNAM-Sintanjin	KYONGSANGNAM-Pusan	KYONGSANGBUK-Waegwan	KYONGSANGBUK-Pohang	KYONGSANGBUK-Daegu	KANGWON-Weonju	KANGWON-Chuncheon	KYONGKI-Dongducheon	KYONGKI-Munsan	KYONGKI-Pyeongtaeg	KYONGKI-Euijeongbu	KYONGKI-Seoul	Relative Abundance (%)
Aedes													
albopictus						X			X				
lineatopennis									X				
vexans	X	X	X	X	X	X	X	X	X	X	X	X	8.8
Anopheles													
lesteri										X			
pullus					X				X				
sinensis	X	X	X	X	X	X	X	X	X	X	X	X	28.2
sineroides	X					X	X	X	X	X	X	X	
Culex													
bitaeniorhynchus	X						X	X		X		X	
mimeticus	X	X			X	X		X		X	X	X	
orientalis	X	X	X		X	X	X	X	X	X	X	X	
pipiens pallens	X	X	X	X	X	X	X	X	X	X	X	X	5.3
rubensis											X		
tritaeniorhynchus	X	X	X	X	X	X	X	X	X	X	X	X	55.4
vagans	X	X	X	X	X	X	X	X	X	X	X	X	

represent the average number of female mosquitoes collected per trap per night. Negative results (i.e. nights when traps were operated but no female mosquitoes collected) were not always reported when samples were sent for identification. The monthly indices are reported only to provide the reader an indication of relative abundance of female mosquitoes occurring in that area during a specific month. These indices should not be erroneously interpreted as a true representation of the mosquito activity in the areas sampled.

III. RESULTS AND DISCUSSION

A total of 65,847 female mosquitoes were collected during 2114 trap nights over a 2 year period (1981-1982) from 5 of 9 Korean provinces using 39 New Jersey Light Traps. Fourteen mosquito species comprising 3 genera were collected and identified (Table 1). The most abundant and widely distributed species collected were *Aedes vexans nipponii*, *Anopheles sinensis*, *Culex pipiens pallens*, and *Culex tritaeniorhynchus*. All of these mosquitoes were collected from each province sampled (Table 2 through 5).

Culex tritaeniorhynchus was the most abundant species collected composing 55.4% of the mosquitoes identified. It is widely distributed over the Republic.

However, the majority of the specimens collected (over 90%) were from the Pyeongtaeg Area. This mosquito is often found associated with *Anopheles sinensis* breeding in such habitats as rice fields, marshes, ground pools, and artificial containers such as cement water tanks and wooden barrels. *Culex tritaeniorhynchus* appeared in collection during July. It reached its peak population levels in August then declining in September. This mosquito is considered to be the primary transmitter of Japanese encephalitis to man. However, James Harwood (1969) reported that Culex tritaeniorhynchus prefers birds and animals as hosts and normally does not attack man until its popula-

Table 2. Summary of Adult Female Mosquito Collected Near Dongduncheon, Euijeongbu, Munsan and Seoul Area Using New Jersey Light Traps, 1981-1982.

Mosquito Species	Year	May	June	July	August	September	October	Total
Aedes albopictus	1981	0	0	1	0	0	0	1
	1982	0	0	0	0	0	0	0
	Total	0	0	1	0	0	0	1
Aedes lineatopennis	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	0	3	3
	Total	0	0	0	0	0	3	3
Aedes vexans nipponii	1981	0	985	403	489	71	0	1948
	1982	13	367	179	473	172	0	1204
	Total	13	1352	582	962	243	0	3152

Anopheles pullus	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	1	2	3
	Total	0	0	0	0	1	2	3
Anopyeles sinensis	1981	0	109	479	742	745	6	2081
	1982	5	223	722	797	132	2	1881
	Total	5	332	1201	1539	877	8	3962
Anopyeles sineroides	1981	0	8	10	0	1	0	19
	1982	0	15	0	0	0	0	15
	Total	0	23	10	0	1	0	34
Culex bitaeniorhynchus	1981	0	0	0	1	2	0	3
	1982	0	0	0	3	0	1	4
	Total	0	0	0	4	2	1	7
Culex mimeticus	1981	0	1	1	0	3	0	5
	1982	0	1	2	1	1	0	5
	Total	0	2	3	1	4	0	10
Culex orientalis	1981	0	2	5	0	2	0	9
	1982	2	5	24	35	22	1	89
	Total	2	7	29	35	24	1	98
Culex pipiens pallens	1981	0	100	93	111	161	13	478
	1982	0	60	280	241	92	28	701
	Total	0	160	373	352	253	41	1179
Culex rubensis	1981	0	0	1	0	0	0	1
	1982	0	0	0	0	0	0	0
	Total	0	0	1	0	0	0	1
Culex tritaeniorhynchus	1981	0	0	23	373	396	4	796
	1982	0	0	205	2674	544	20	3443
	Total	0	0	228	3047	940	24	4239
Culex vagans	1981	0	330	7	0	0	0	337
	1982	327	313	8	0	0	0	648
	Total	327	643	15	0	0	0	985
	Monthly Total	347	2519	2443	5940	2348	77	13674
	Total Trap Night	40	239	246	244	198	66	1033
	Monthly Trap Index	8.7	10.5	9.9	24.3	11.9	1.2	13.2

Table 3. Summary of Adult Female Mosquito Collected Near Sintanjin and Pyeongtaeg Area Using New Jersey Light Traps, 1981-1982.

Mosquito Species	Year	May	June	July	August	September	October	Total
Aedes vexans nipponii	1981	4	1536	169	50	4	0	1763
	1982	18	343	96	49	0	0	506
	Total	22	1879	265	99	4	0	2269
Anopheles lesteri	1981	0	0	0	3	0	0	3
	1982	0	0	0	0	0	1	1
	Total	0	0	0	3	0	1	4
Anopheles sinensis	1981	0	186	3060	2462	247	9	5964
	1982	3	1330	2927	2534	116	5	6915
	Total	3	1516	5987	4996	363	14	12879
Anopheles sineroides	1981	0	0	4	0	0	0	4
	1982	0	2	0	0	0	0	2
	Total	0	2	4	0	0	0	6
Culex bitaeniorhynchus	1981	0	0	3	4	0	0	7
	1982	0	0	0	0	0	0	0
	Total	0	0	3	4	0	0	7
Culex mimeticus	1981	0	0	1	0	0	0	1
	1982	0	0	0	0	0	0	0
	Total	0	0	1	0	0	0	1
Culex orientalis	1981	0	2	0	0	0	0	2
	1982	0	1	4	2	1	1	9
	Total	0	3	4	2	1	1	11
Culex pipiens pallens	1981	0	210	565	177	148	20	1120
	1982	1	65	305	48	49	25	493
	Total	1	275	870	225	197	45	1613
Culex tritaeniorhynchus	1981	0	0	142	3064	1805	7	5018
	1982	0	10	1471	22887	800	9	25177
	Total	0	10	1613	25951	2605	16	30195
Culex vagans	1981	0	137	6	0	0	3	146
	1982	81	73	1	0	0	0	155
	Total	81	210	7	0	0	3	301
Monthly Total		107	3895	8754	31280	3170	80	47286
Total Trap Night		52	141	136	161	127	55	672
Monthly Trap Index		2.1	27.6	64.4	194.3	25.0	1.5	70.4

Table 4. Summary of Adult Female Mosquito Collected Near Wonju and Chuncheon Area Using New Jersey Light Traps, 1981-1982.

Mosquito Species	Year	May	June	July	August	September	October	Total
Aedes albopictus	1981	0	0	0	0	0	0	0
	1982	0	0	0	1	0	0	1
	Total	0	0	0	1	0	0	1
Ades vexans nipponii	1981	5	5	10	21	1	0	42
	1982	1	48	45	128	23	0	245
	Total	6	53	55	149	24	0	287
Anopheles sinensis	1981	0	0	80	53	9	1	143
	1982	0	46	110	50	11	1	218
	Total	0	46	190	103	20	2	361
Anopheles sineroides	1981	0	0	0	0	0	0	0
	1982	0	1	0	0	0	0	1
	Total	0	1	0	0	0	0	1
Culex bitaeniorhynchus	1981	0	0	0	0	1	0	1
	1982	0	0	0	0	0	2	2
	Total	0	0	0	0	1	2	3
Culex orientalis	1981	0	0	0	0	0	0	0
	1982	0	1	3	5	2	0	11
	Total	0	1	3	5	2	0	11
Culex pipiens pallens	1981	0	0	5	16	10	4	35
	1982	0	8	107	96	22	5	238
	Total	0	8	112	112	32	9	273
Culex tritaeniorhynchus	1981	0	0	0	9	5	3	17
	1982	0	0	9	140	22	1	172
	Total	0	0	9	149	27	4	189
Culex vagans	1981	0	2	0	0	0	0	2
	1982	0	2	2	0	0	0	4
	Total	0	4	2	0	0	0	6
Monthly Total		6	113	371	519	106	17	1132
Total Trap Night		2	16	27	26	20	10	101
Monthly Trap Index		3.0	7.1	13.7	20.0	5.3	1.7	11.2

Table 5. Summary of Adult Female Mosquito Collected Near Pusan, Daegu, Pohang and Waegwan Area Using New Jersey Light Traps, 1981-1982.

Mosquito Species	Year	May	June	July	August	September	October	Total
Aedes vexans nipponii	1981	0	3	3	2	0	0	8
	1982	0	1	24	33	10	0	68
	Total	0	4	27	35	10	0	76
Anopheles pullus	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	0	1	1
	Total	0	0	0	0	0	1	1
Anopheles sinensis	1981	0	23	555	91	3	0	672
	1982	0	31	370	256	22	0	679
	Total	0	54	925	347	25	0	1351
Culex mimeticus	1981	0	0	0	0	0	0	0
	1982	0	0	1	0	0	0	1
	Total	0	0	1	0	0	0	1
Culex orientalis	1981	0	0	0	0	0	0	0
	1982	0	0	5	0	0	0	5
	Total	0	0	5	0	0	0	5
Culex pipiens pallens	1981	0	38	136	71	10	0	255
	1982	0	53	90	16	18	0	177
	Total	0	91	226	87	28	0	432
Culex tritaeniorhynchus	1981	0	10	4	51	7	0	72
	1982	5	0	79	1460	239	5	1788
	Total	5	10	83	1511	246	5	1860
Culex vagans	1981	0	15	4	0	0	0	19
	1982	5	0	5	0	0	0	10
	Total	5	15	9	0	0	0	29
Monthly Total		10	174	1276	1980	309	6	3755
Total Trap Night		2	63	98	98	35	12	308
Monthly Trap Index		5.0	2.8	13.0	20.2	8.8	0.5	12.2

tions occur in large numbers. Due to this vector-host relationship, mosquito and man, there are probably other indigenous mosquito species that are involved in the Japanese encephalitis transmission cycle.

Anopheles sinensis, specimens collected comprised 28.2% of the 2 year collection. *Anopheles sinensis* 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. *Anopheles sinensis* populations normally peaked during July and declined in August when *Culex tritaeniorhynchus* populations increased. Although *sinensis* levels decreased in August, its still remained the second most abundant species. This mosquito is the vector of vivax malaria and inland Brugian filariasis.

Aedes vexans nipponii, a possible vector of Japanese encephalitis, comprised 8.8% of specimens collected. In Korea, this mosquito is found breeding in rice fields, ground pools, and ponds where *Anopheles sinensis* and *Culex tritaeniorhynchus* also occur. *Aedes vexans nipponii,* although widely distributed throughout Korea, was collected primarily in northern part of the Republic. It usually appeared in May and reached its peak population levels in June then declining throughout the summer. This mosquito often appeared to have multiple population peaks during July and August, but of lower magnitude than that observed in June. Shin, et al., (1971) observed a similiar phenomenon with its highest peak in July and lower peaks in June and August.

Culex pipiens pallens may be a potential vector of Japanese encephalitis. Although widely distributed and frequently collected, it comprised only 5.3% of the specimens identified. *Culex pipiens pallens* breeds in open water habitats where *nipponii, sinensis* and *tritaeniorhynchus* are found. However, *pallens* prefers sites where tends to be more stagnant with a higher organic content such as sewage ditches.

Anopheles lesteri is a potential vector of vivax malaria and possibly inland Brugian filariasis. This species was collected in very low numbers during this period. Harrisons (1973) reported that *Anopheles lesteri* may be a more important vector of malaria than *sinensis.* The number of *Anopheles lesteri* specimens collected and identified may be incorrect as *lesteri* is morphologically and taxonomically very similiar to *sinensis* and is often misidentified as *sinensis.* It is note-worthy to point out that the *Anopheles lesteri* (?) specimens identified were only collected from Pyeongtaeg Area. Future collections of *Anopheles sinensis* from the Pyeongtaeg Area will be more closely checked for *lesteri.* Until the characteristics seperating these species are more clearly defined and taxonomic position of *lesteri* is better understood, the correct distribution and abundance of *lesteri* in Korea will not be accurately known.

Culex bitaeniorhynchus, a vector of Japanese encephalitis, was collected in very low numbers. The numbers collected in light traps would seem to indicate that this mosquito species may not be a significant threat as a vector of Japanese encephalitis. However, it is possible that this species is not readily attracted to light traps and its population levels could be higher than our results indicate.

The remaining 8 species were only collected in low numbers. All of these species are considered to be nuisance pests and have not been associated with any mosquito-borne diseases.

The US Army uses malathion as its primary pesticide to control both larvae and adult mosquitoes occurring in the Republic of Korea. Malathion is applied as an Ultra Low Volume (ULV) droplet for adult mosquito control and a spray to breeding site for larvae control. Shim, et al. (1982) found that 1,091.44 ppm (parts per million) .of malathin were required to achieve a lethal concentration dose to kill 95% (LC95) of the *Culex tritaeniorhynchus* larvae tested. This study indicates malathion is not effective against the larvae of this mosquito with probable similiar results for the adults. The resistance of *Culex tritaeniorhynchus* to malathion is due to the wide of other closely related organophosphate compounds by rice farmers to control agricultural pests of rice. It is also possible that *Anopheles sinensis, Aedes vexans nipponii*, and *Culex pipiens pallens* could be resistant to malathion because they also breed in rice field.

The use of biological control agents is rapidly gaining acceptance because of the increasing incidence of resistance to chemical pesticide and the biological agents may provide a better long term solution in controlling vector populations. The important aspect of these biological agents is their positive impact on the environment by reducing the hazards imposed by chemicals and controlling mosquitoes.

Studies by Yu, et al (1977 and 1979) have shown the use of predaceous fishes and Planarians to reduce mosquito populations and other biting flies that breed in aquatic habitats. Self, et al. (1973) discovered that frequent draining and flooding practices used to increase rice production also resulted in the reduction of *Culex tritaeniorhynchus* populations. The use of non-chemical methods for controlling mosquitoes such as biological agents and habitat manipulation should be encouraged and used wherever possible in light of the continued development of chemical resistance in rice field breeding mosquitoes.

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