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Population Dynamics of Malaria Vector Mosquito *Anopheles sinensis* in Kyongbuk, Korea (1996-1998)*

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Abstract : In order to study the population dynamics of malaria vector mosquitoes, *Anopheles sinensis,* average numbers of female mosquito per trap-night were enumerated during the period of 3 years from 1996 to 1998. As in the general patterns of seasonal prevalence, *Anopheles sinensis* was first collected between late March and mid-May and was trapped in large numbers between 27th June and 19th July, showing a simple sharply pointed one-peaked curve. On the other hand, *Culex pipiens pallens* was found to be active thoughout almost entire season, showing irregular curves with several peaks. *Culex tritaeniorhynchus* first appeared between 8th June and 14th July and was trapped in large number during the period September of 5th and 18th, The number of trapped mosquitoes began to decrease from early October and a few were collected until early November in 1996 and 1998. The average number of *Anopheles sinensis* rapidly decreased in July as compared with average standard year, and the number was particular low in 1996. The number of *Culex tritaeniorhynchus* in September was 158.9 per trap-night in 1996, however, abruptly decreased to 80.8 in 1997 and then increased to 237.4 in 1998. The total number of *Culex pipiens pallens* abruptly increased during the 3 months from May to July in 1997, followed by a decrease. A marked decrease on mean percent index (MPI) was obtained in 1998. The above results indicate that the population density of *Anopheles sinensis* and *Culex tritaeniorhynchus* in Kyongbuk Province was increasing during the three years from 1996 to 1998, while *Culex pipiens pallens* abruptly decreased in 1998.

Key Words : *Anopheles sinensis, Culex tritaeniorhynchus, Culex pipiens pallens,* Seasonal prevalence, Population dynamics, Kyongbuk Province.

* The study was presented at the 40th annual meeting of the Korean Society for Parasitology (1998).

Introduction

Since the early twentieth century, vector mosquitoes have been known as a public health pest not only to cause serious nuisance, but also to act as the transmitter of malaria, filariasis, viral encephalitis and others. After Hasegawa's first report[1], many investigators reported a considerable number of patients suffering from malaria, filariascs, encephalitis and their vector mosquitoes in Korea.

In the 1940s-50s, the concentration of population in urban areas and unsanitary conditions resulted in increased incidence of many arthropod-borne diseases to such extent that they became the major public health problems of nationwide significance. Since the beginning of the Saemaul movement in the early 1970s, the Korean Government instituted plans to attain self-sufficient rice production by practicing land reclamation and cultivating hilly areas in combination with the establishment of an irrigation system, improvement of agricultural technique, and no paragraph intense use of agricultural chemicals. These operations inevitably resulted in the expansion of mosquito larval habitats, and brought important changes in the agroecosystems which foreordain the distribution and abundance of mosquitoes. To establish effective control measures of mosquito-borne diseases such as malaria, Malayan filariasis, Japanese encephalitis and others, epidemiological, ecological, and entomological studies on these diseases in some rural villages and U.S. military installations in Korea have been conducted since 1970.

Entomological studies on vector mosquitoes of these diseases in Kyongbuk have been carried out by many investigators, since Kanda *et al.*[2] found some positive cases of Malayan microfilaremia during blood surveys. According to previous studies, *C. tritaeniorhynchus* first appeared in mid-June and was trapped in large numbers during the period of mid-August to early September with a sharply pointed peak curve, whereas *C. pipiens pallens* was active throughout almost the entire season, showing irregular curve with several peaks. As for *A. sinensis,* the trend was similar to that of *C. tritaeniorhynchus,* but the earliest dates of appearance and disappearance differed from those of *C. tritaeniorhynchus*. Joo and Kang[3] reported that the population density of *A.sinensis* in Kyongbuk Province was decreasing over the five-year period from 1987 to 1991.

In recent years, some cases of malaria and few cases of Japanese encephalitis have been noted in Korea. Even though these diseases have been considered to have disappeared spontaneously in the past few decades in parallel with improvements in general sanitation, there now appears to exist a number of small isolated foci in rural areas and lack of attention given to the problem of mosquito-borne diseases. The present study was undertaken as a part of our investigation on the epidemio-entomology and control of mosquito-borne diseases, and attempted to estimate population dynamics of vector mosquitoes in Kyongbuk Province during the period from 1996 to 1998.

Materials and Methods

Surveyed areas: Kyongbuk Province is located in the southeast part of Korean peninsula, covering an area of 19,700 square kilometers (Fig.1), and Keimyung University training farm in Kyongsan city was selected as main survey station.

Some rural villages situated in the surrounding rice paddies in the Province were selected as other study areas, because of the presence of main breeding places for the vector mosquitoes. More detailed geographical features have been presented by Baik and Joo[4], Kang and Joo[5], Joo and Lyuh[6], and Lee *et al.*[7].

Meteorological data: The surveyed areas are under the influence of a typical

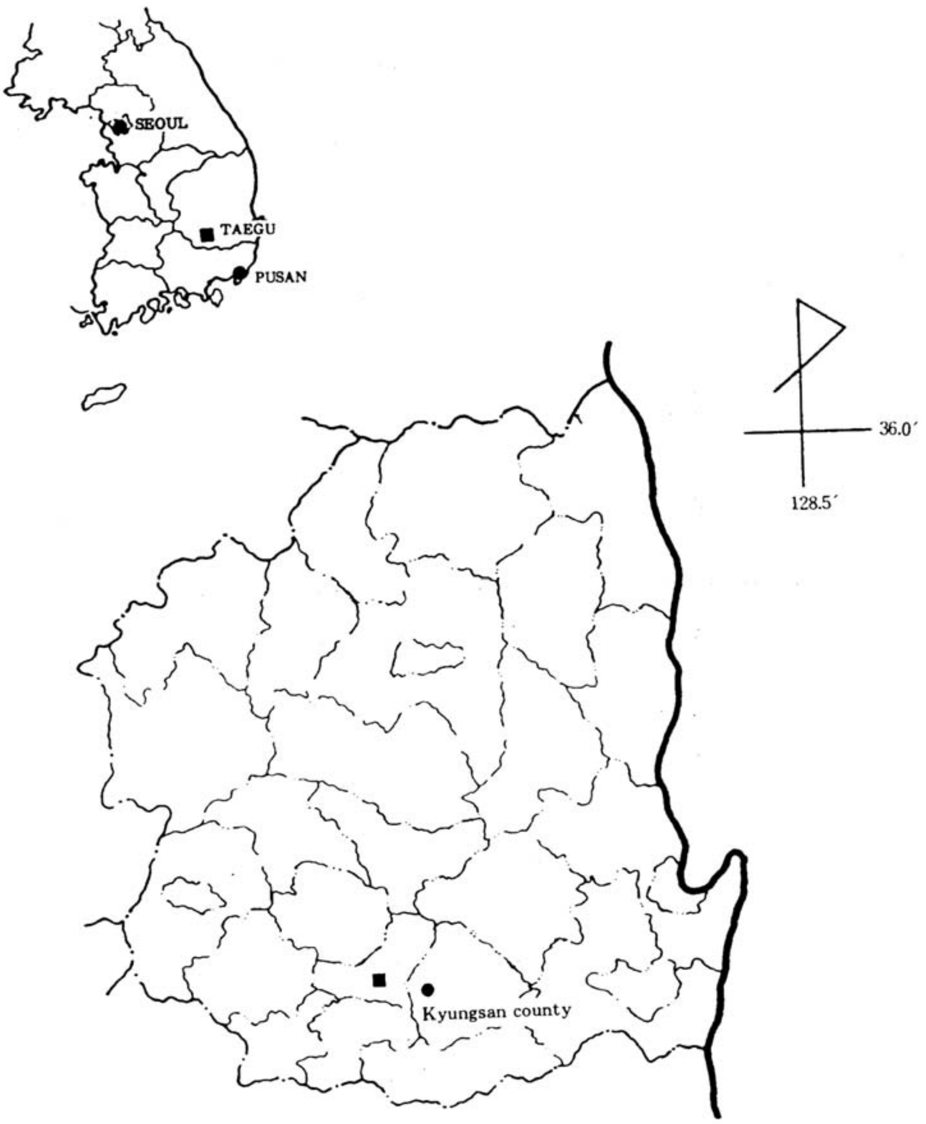

Fig. 1.

continental climate of the eastern coast, affected by both high atmospheric pressure from the cold continent and low one from the Pacific Ocean in the summer season. Therefore, seasonal fluctuation of air temperature and precipitation, which is of fundamental importance to understand population dynamics of the vector mosquitoes is very great. Meteorological data for the period of the persent survey was provided by the Taegu branch of the Korea Meteorological agency.

Light trap operation: Light trap collections were performed as follows: A light trap was fixed at 1.5 m above the ground at trapping spots, such as the piggery A, the cow-shed B, and the dwelling-house C, and was operated from dusk to down on one-night per week schedules. Mosquitoes collected at each station were counted by species.

Indices of Mosquito abundance: In order to compare the seasonal and annual abundance of vector mosquitoes, mean percent index (MPI), which was proposed by Maeda *et al.*(8), was used. MPI is calculated by the following procedure.

If the total number of mosquitoes collected by m-time collection at a station of i in a year of k is given by

$$X_{ik} = \sum_{j=1}^{m} X_{ijk},$$

where X_{ijk} is the number of mosquitoes collected at each station, MPI is shown in the following equation :

$$MPI_k = \frac{100}{n} \sum_{X=1}^{n} (X_{ik}/X_{io})$$

Where n is the number of station and X_{io} is the total number of mosquitoes collected at each station in the standard year (1986), when the stations for the collection were being fixed.

Seasonal prevalence can be also expressed in MPI from the data of light trap collections as follows :

$$MPI_{jk} = \frac{MPI_k}{n} \sum_{i=1}^{n} (X_{ijk}/X_{ik}).$$

Results

The earliest dates when the vector mosquitoes began to be collected by light traps during three years in Kyongsan city, Kyongbuk Province, and the air temperature and humidity at that time are listed in Table 1.

A. sinensis began to be collected on 16th May in 1996, but on 13th March in 1997 and 7th April in 1998. At that time the air temperature ranged from 6.0-31℃ and humidity from 50 to 60 per cent. The average number of *A. sinensis* per trap-night was 0.3 to 4.0. During the period from 1996 to 1998, the trine when *C. tritaeniorhynchus* firstly appeared in the light traps was consistently between 13th and 27th in June. The air temperature at that time ranged from 19.2-30.3℃ and humidity from 69 to 79 per cent. *C. pipiens pallens* was first collected in the light traps on 2th May in 1996, but between 6th and 14th in April in 1997 and 1998. The temperature ranged from 2.8 to 25.7℃ and humidity from 34 to 51 per cent. The average number of *C. pipiens pallens* per trap-night was 0.3 to 0.7.

Table 1. Three years′ observation of the earliest dates when three main vector mosquitoes began to appear in Kyongsan city, together with meteorological data (1996-1998)

Species	Year	Earliest date when mosquito appeared		Temperature (Range,℃)	Humidity (%)	Average No./ trap-night
A. sinensis	1987*	April	2	3.3-16.1	55	0.7(2/3)**
	1996	May	16	12.6-31.3	50	4.0(12/3)
	1997	March	13	7.5-20.6	60	3.3(10/3)
	1998	April	7	6.0-23.1	53	0.3(1/3)
C. tritaeniorhynchus	1986*	June	12	12.0-28.8	65	0.3(1/3)
	1996	June	13	19.2-29.4	71	0.7(2/3)
	1997	June	27	22.7-30.3	79	0.3(1/3)
	1998	June	23	20.0-28.8	69	0.3(1/3)
C. pipiens pallens	1986*	April	10	14.0-23.7	61	0.3(1/3)
	1996	May	2	13.4-25.7	42	0.3(1/3)
	1997	March	27	2.8-20.5	51	0.7(2/3)
	1998	March	24	4.2-14.6	34	0.7(2/3)

* Data of standard year reported by Joo and Kang [3] and Baik and Joo [4]

** Number in parentheses represents the total number of female mosquitoes per trap-night.

Table 2 shows the dates in each year for the first appearance of newly-emerged males, based on the collection by light traps. Since only females overwinter, the appearance of a new generation of vector mosquitoes is represented by males and varied greatly from year to year. The earliest date for the first appearance of male *A. sinensis* was between 1st and 28th in May. The first appearance of male *C. tritaeniorhynchus* was June 17th in 1997 and the latest one July 14th in 1996.

The dates of male *C. pipiens pallens* in the light traps was consistently between the 15th and 28th in May. At that time, the air temperature ranged from 10.9 to 31.3℃.

The dates when maximum numbers of three main vector mosquitoes were collected in the light traps are listed in Table 3. The highest population density of *A. sinensis* from 1996 to 1998 was observed during the period from late June to mid-July. The air temperature was between 22.7 and 36.8℃ and relative humidity from 61 to 79 per cent. The maximum number of *A. sinensis* in 1996 was 519.0 per trap-night. In 1997, the number increased to 521.0 and 925.7 in 1998.

In the case of *C. tritaeniorhynchus,* the maximum number in 1996 was 318.0 per trap-night. In 1997, the number decreased to 130.3 and increased again to 551.7 in 1998. The high density of *C. pipiens pallens* was encountered during the period from mid-June to mid-July. The maximum number in 1996 was 567.0 per trap-night. The density markedly increaseed and

Table 2. Date for the first appearance of newly-emerged male vector mosquitoes and meteorological data at that time (1996-1998)

Species	Year	Date of frist appearance	Temperature (Range ℃)	Humidity (%)
A. sinensis	1987*	June 4	19.0-35.1	65
	1996	May 9	8.3-24.7	41
	1997	May 1	9.9-28.8	46
	1998	May 28	10.9-28.2	55
C. tritaeniorhynchus	1986*	July 31	5.7-21.3	44
	1996	July 14	19.7-30.2	75
	1997	June 17	21.2-27.6	72
	1998	July 7	24.1-33.6	61
C. pipiens pallens	1986*	May 8	13.4-29.0	44
	1996	May 16	12.6-31.3	50
	1997	May 15	20.2-29.3	66
	1998	May 28	10.9-28.2	55

Table 3. Date of peak population of three main vector mosquitoes and meteorological data at that time (1996-1998)

Species	Year	Date of peak population	Temperature (Range,℃)	Humidity (%)	Average No./ trap-night
A. sinensis	1987*	July 9	21.7-34.8	59	1,247.0(3,741/3)
	1996	July 19	25.0-36.8	64	519.0(1,557/3)
	1997	June 27	22.7-30.3	79	521.0(1,563/3)
	1998	July 7	24.1-33.6	61	925.7(2,777/3)
C. tritaeniorhynchus	1986*	August 14	22.2-30.9	81	171.7(515/3)
	1996	September 5	20.0-26.5	73	318.0(954/3)
	1997	September 18	16.6-27.5	57	130.3(391/3)
	1998	September 15	20.3-31.5	61	551.7(1,655/3)
C. pipiens pallens	1986*	July 25	22.0-28.3	84	1,227.0(3,831/3)
	1996	July 19	25.0-36.8	64	567.0(1,701/3)
	1997	June 17	21.2-27.6	72	1,388.7(4,166/3)
	1998	July 7	24.1-33.6	61	880.3(2.641/3)

reached a maximum of 1,388.7 in 1997. In 1998, the number decreased to 880.3.

In Table 4, the dates when vector mosquitoes were not collected in the surveyed area are listed according to the year studied. *A. sinensis* was not observed in the area early and mid-November, but *C. tritaeniorhynchus* in mid-October and early

November. *C. pipiens pallens* was not collected in late November and early December. The air temperature at that time ranged from -1.7 to 24.8℃ and humidity from 42 to 72 per cent.

The seasonal variations of three main vector mosquitoes collected by the light traps are summarized in Table 5. In general, *A. sinensis* was collected in The duration of 6 to 8 months, and *C. tritaeniorhynchus* was collected in 5 months, from June to October every year. *C. pipiens pallens* was collected in 8 or 9 months, from March or April to November or December. The general patterns of monthly and yearly changes of the vector mosquitoes were found to vary greatly by species.

In 1997, however, average number of female *A. sinensis* per trap-night in April, 1992 was 0.3, it increased to 3.5 in May, 213.8 in June, and reached the maximum number 300.2 in July. In August, the average decreased to 114.0, to 50.7 in September to 2.2 in October and to 0.1 in November.

The general patterns of seasonal variations of *A. sinensis* in the other years are similar to those in 1997, but the dates of appearance and disappearance differed from those of 1997. The average number of female *A. sinensis* in April, 1997 was 0.3, and the average in 1998 increased to 1.2, however, it was not collected in April, 1996 and in November, 1996 and 1998.

C. tritaeniorhynchus first appeared in June with on average number of 0.1-9.9, and it subsequently increased to 80.8-158.9 in September, 1996-1997 and reached a maximum of 323.2 in August, 1998. The trend of seasonal distribution of female *C. pipiens pallens* was similar to that of *A. sinensis,* but the dates of appearance and disappearance differed from that of *A. sinensis.*

Relative abundance and MPI calculation

Table 4. Date of disappearance of three main vector mosquitoes and meteorological data (1996-1998)

Species	Year	Date of disappearance of vector mosquito		Temperature (Range,℃)	Humidity (%)
A. sinensis	1987*	November	19	2.6-13.0	39
	1996	November	7	2.6-11.2	71
	1997	November	13	10.7-13.3	62
	1998	November	3		
C. tritaeniorhynchus	1986*	October	2	11.5-17.4	83
	1996	November	7	2.6-11.2	71
	1997	October	16	8.5-24.8	56
	1998	November	3		
C. pipiens pallens	1986*	November	20	4.5-13.5	42
	1996	November	28	-1.7- 7.1	42
	1997	November	27	6.2-13.4	51
	1998	December	8	-0.9- 5.8	44

Table 5. Seasonal variations of vector mosquitoes by average number collected in each trap during three years in Kyongsan city, Kyongbuk Province (1996-1998)

Species	Year	Average No. of female mosquito per trap-night							
		Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
A. sinensis	1987*	0.1	0	108.2	542.6	50.8	18.1	0.4	0.1
	1996	0	3.0	49.0	216.4	66.1	47.8	1.7	0
	1997	0.3	3.5	213.8	300.2	114.0	50.7	2.2	0.1
	1998	1.2	6.4	183.7	376.9	154.4	84.7	3.7	0
C. tritaeni-orhynchus	1986*	0	0	0.2	17.9	113.8	63.4	0.1	0
	1996	0	0	0.3	3.3	41.0	158.9	0.5	0
	1997	0	0	0.1	6.8	55.3	80.8	2.2	0
	1998	0	0	9.9	115.0	323.2	237.4	2.0	0
C. pipiens pallens	1986*	1.3	6.3	153.8	889.5	559.3	170.3	3.6	0.3
	1996	0	9.5	242.6	401.2	223.1	245.7	18.1	1.2
	1997	0	45.7	770.4	862.4	386.8	65.8	3.6	1.0
	1998	8.7	51.5	162.1	444.4	169.8	48.6	4.3	4.0

for three main vector mosquitoes in consecutive years since 1996 are shown in Table 6 and illustrated by Fig. 2. The total number of A. sinensis progressively increased during the three years from 1996 to 1998. A marked decrease in MPI was obtained in 1996 and increased to 75.6 in 1997 and to 90.9 in 1998. However, MPI of *C. tritaeniorhynchus* and *C. pipiens pallens* varied greatly from year to year.

Table 7 shows the results on the number of total and engorgement rates of three main female mosquitoes collected by the light traps at three locations during three years from 1996 to 1998. The overall rate of engorgement, as calculated by dividing the number engorged with the total, which reflects the efficiency of blood-sucking activity of vector mosquitoes, varied greatly depending on species. The overall engorgement rates of *A. sinensis* in 1996 were 26.5 per cent on cow-stall, 22.1 per cent on piggery, and 0.2 per cent on house- dwelling. The general patterns of engorgement rates in the other years were similar to those of 1996, but was not in 1997.

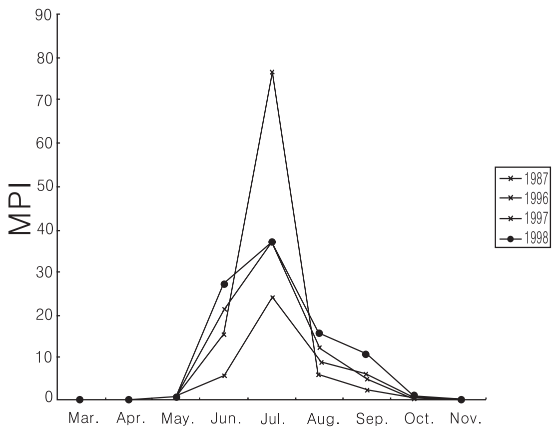

Fig. 2-1. Annual prevalence of *Anopheles sinensis,* as shown by MPI calculated from the data of mosquitoes collected at 3 stations. Standard year : 1987

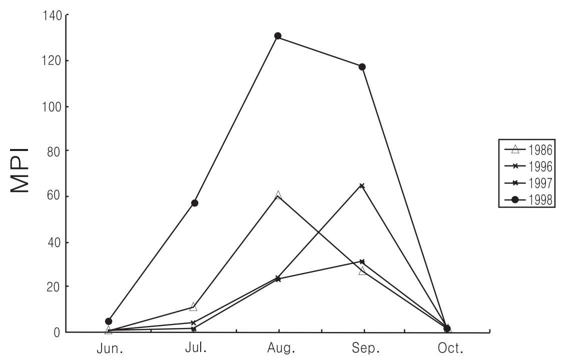

Fig. 2-2. Annual prevalence of *Culex tritaeniorhynchus,* as shown by MPI calculated from the data of mosquitoes collected at 3 stations. Standard year : 1986

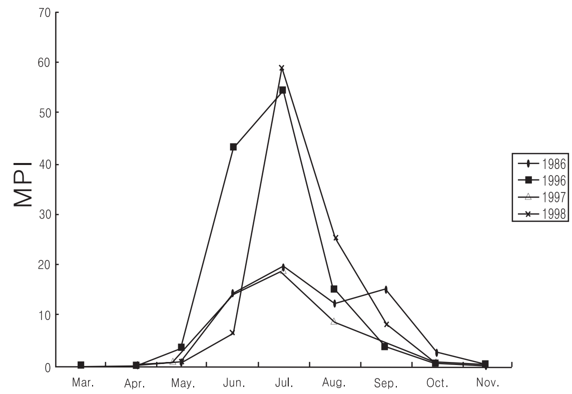

Fig. 2-3. Annual prevalence of *Culex pipiens pallens,* as shown by MPI calculated from the data of mosquitoes collectied at 3 stations. Standard year : 1986

Table 6. Relative abundance of three main vector mosquitoes in consecutive years since 1996

Year	At 3-stations located in Kyungsan city					
	A. sinensis		*C. tritaeniorhynchus*		*C. pipiens pallens*	
	Total	MPI	Total	MPI	Total	MPI**
Standard Y*	10,242	100.0	2,398	100.0	24,126	100.0
1996	4,820	44.9	2,572	90.7	14,447	65.0
1997	9,145	75.6	1,768	59.8	28,367	120.1
1998	10,353	90.9	8,981	315.5	11,185	48.7

* Data of standard year reported by Joo and Kang[3] and Baik and Joo[4].

** MPI represente mean percent index.

The seasonal variations of engorgement rates of three main vector mosquitoes collected by the light traps in each year from 1996 to 1998 are summarized in Table 8. The engorgement rates varied greatly depending on species and months each year. Of the vector mosquitoes, the blood -sucking rates of *A. sinensis* were 2.2-11.3 per cent in May, 20.3-56.6 per cent in June, 19.7-45.5 per cent in July, 22.2-31.4 per cent in August, 15.7-36.3 per cent in September, and 0-27.3 per cent in October, respectively. The rates of *C. tritaeniorhynchus* were 17.5-61.8 per cent in July, 21.8-47.8 per cent in August and 25.1-74.4 per cent in September, although the rates decreased in October and was kept at the level of 30.0 per cent.

The engorgement rates of *C. pipiens pallens* in 1996 were the highest rate in June with 1.5 per cent, followed by May with 0.7 per cent and July with 0.6 per

Table 7. Comparison of engorgement rates of three main vector mosquitoes collected by light traps at piggery A, cow-stall B, and house-dwelling C during three years of 1996-1998

Year	Location	*A. sinensis*		*C. tritaeniorhynchus*		*C. pipiens pallens*	
		No. collected	% engorged	No. collected	% engorged	No. collected	% engorged
Standard*	A	3,492	29.6	1,095	50.0	14,200	0.8
	B	5,206	38.7	1,176	41.2	7,315	1.8
	C	1,544	5.8	127	7.1	2,611	0.5
	Subtotal	10,242	30.7	2,398	43.4	24,126	1.1
1996	A	1,714	22.1	1,440	52.8	4,407	0.8
	B	2,536	26.5	1,069	46.4	8,946	0.5
	C	570	0.2	63	3.2	1,085	0.1
	Subtotal	4,820	21.8	2,572	48.9	14,438	0.6
1997	A	4,025	36.5	924	66.3	8,366	0.6
	B	4,828	55.9	811	62.3	18,863	0.7
	C	292	0.0	33	6.1	1,138	0.2
	Subtotal	9,145	45.6	1,768	63.3	28,367	0.6
1998	A	3,766	26.0	5,402	28.5	3,420	0.8
	B	5,749	22.3	3,367	19.4	7,116	0.6
	C	838	0.1	212	2.8	649	0.2
	Subtotal	10,353	21.8	8,981	24.5	11,185	0.6

* Data of standard year reported by Joo and Kang(1992) and Baik and Joo(1991).

Table 8. Seasonal variations of engorgement rate of vector mosquitoes collected by light trap (1996-1998)

Species	Year	April		May		June		July
		No. collected	%	No. collected	%	No. collected	%	No. collected
A. sinensis	1987*	1	0	0	0	1,298	10.5	8,112
	1996	0	0	45	2.2	588	22.8	2,597
	1997	3	0	53	11.3	2,566	56.6	4,503
	1998	14	35.7	77	7.8	2,572	20.3	4,523
C. tritaeni-	1986*	0	0	0	0	9	11.1	604
orhynchus	1996	0	0	0	0	3	0	40
	1997	0	0	0	0	1	0	102
	1998	0	0	0	0	138	42.0	1,380
C. pipiens	1986*	12	0	120	1.7	1,846	0.91	3,343
pallens	1996	0	0	143	0.7	2,911	1.5	4,814
	1997	0	0	686	0	9,245	0.51	2,936
	1998	104	0	618	0.5	2,269	0.5	5,333

cent. The rates in the other years were similar to those for 1996.

Discussion

This is a report on a complete year's collection with one night per week schedules, and appearance time of female mosquitoes from hibernation seems to depend on the time of awakening from winter diapause, and varies from year to year, probably due to different air temperature in of each year 's early spring. The appearance of a new generation of vector mosquitoes is indicated by male mosquitoes, since only female mosquitoes overwinter.

The earliest dates in each year for the appearance of newly-emerged male mosquitoes, shown in Table 2, were based on the light trap collections.

Table 2 indicates that the appearance time of the first male mosquitoes was greatly different from year to year, depending on the time of oviposition by over-wintering females as well as the condition, particularly the temperature, during the immature stages.

The biological, ecological, sero-epidemiological, and virological studies on the vector mosquitoes in Korea have made remarkable progress through the labors of medical parasitologists and entomologists serving with the American military services after World War II. During the JE epidemics among the residents on Korea in 1946-1949, Sabin *et al.*[9] conducted a study on American soldiers in the Kun-san area, and successfully isolated JE virus from a patient who died. A study of Hullinghorst *et al.*[10] indicated that the sera of normal Koreans subjected to

	August		September		October		November	
%	No. collected	%	No. collected	%	No. collected	%	No. collected	%
35.6	609	16.1	217	9.2	4	0	1	0
23.4	991	22.2	573	15.7	26	0	0	0
45.5	1,368	31.4	608	36.3	33	27.3	1	0
19.7	1,853	30.5	1,270	21.6	44	2.3	0	0
44.4	438	23.3	1,055	41.2	18	11.1	0	0
17.5	615	44.1	1,907	51.3	7	28.6	0	0
61.8	663	47.8	969	74.4	33	57.6	0	0
28.8	3,878	21.8	3,561	25.1	24	25.0	0	0
0.5	6,712	0.9	2,692	4.2	54	1.9	4	0
0.6	3,346	0.2	2,948	0.2	271	0	14	0
0.8	4,642	0.7	790	0.4	54	0	12	0
0.5	2,037	0.8	729	1.9	52	3.8	36	0

anamnestic evaluation and specimens from domestic animals showed wide dissemination of the virus in Korea.

Lee *et al.*[11] reported that *C. pipiens pallens* was the most prevalent species, and *A. sinensis* was next in order. with *C. tritaeniorhynchus* being the fourth. As for the seasonal variation in numbers of the vector mosquitoes in Korea, there has been an attempt earlier to estimate the population dynamics of *A. sinensis, C. tritaeniorhynchus, C. pipiens pallens* and others. Seasonal variations of vector mosquitoes have been usually shown by the number of mosquitoes collected, but the numbers were found to fluctuate by day and place, as well as by collection method. Therefore, the total or mean values seem not to be accurate for comparison of the annual abundance of mosquito population.

Considering these drawbacks, Ishii and Karoji[12] conducted a survey of population dynamics of vector mosquitoes by using trap collection and proposed the use of collection index, and trap index estimated from the data obtained by right trap collection, and calculated the relative error of these indices by Morisita's Iσ method[13]. However, it was obvious that large variations among many stations in the number of vector mosquitoes collected should be taken into consideration for comparison of annual abundance of mosquitoes. In fact, most of vector mosquitoes in rural and suburban areas have habitats which are suitable for breeding larvae of mosquitoes. Therefore, total number of certain mosquitoes species collected at different stations may not always represent the relative number of that species. In order to solve such a problem, Maeda *et al.*[8] proposed to use mean percent index (MPI), which can be calculated from the data of mosquito collections, for comparison of the annual abundance of mosquitoes. They also reported that *C. tritaeniorhynchus* decreased after 1965 and this decrease was correlated with reduction of human patients of Japanese encephalitis in Japan.

Entomological surveys of mosquito population in Kyongbuk Province, Korea, have been carried out by some investigators in successive years since 1984[2-7, 11, 15-17]. Although these data are valuable, however, they have not been used. for further analysis of the epidemic of Japanese encephalitis, malaria and filariasis. These data indicated remarkable decrease of vector mosquitoes in recent years and the tendency of the decrease not only in Kyongbuk Province, but also all over Korea. It seems very likely, therefore, that the decrease of these vector mosquitoes are an important factor in the reduction of human cases with mosquito transmitted diseases, such as Japanese encephalitis, malaria, filariasis and others in Korea. Main reasons for the decrease of number of vector mosquitoes are numerous, however, there are several importent factors, such as spraying of insecticides including other toxic chemicals, extensive use of herbicides such as CNP and NIP for rice plant cultivations, and introduction of intermittent irrigation or the early planting of rice plants.

As for the host preference of vector mosquitoes, Sasa *et al.*[18] reported the attraction order of animals to vector mosquitoes, estimated by using animal-baited traps following: horse > goat > rabbit > chicken for *A. sinensis* and *A. vexans nipponii,* horse > goat > chicken > rabbit for *C. tritaeniorhynchus,* and chicken > horse > goat > rabbit for *C. pipiens pallens.* Wada *et al.*[19] in their studies on vector mosquitoes of Japanese encephalitis found that *C. tritaeniorhynchus* was strongly zoophilic and probably in a lesser extent ornithophilic, *A. sinensis* was highly zoophilic, and *C. pipiens pallens* was anthropophilic and ornithophilic species.

Observed blood-feeding success of vector mosquitoes sometimes is a reflection of relative mosquito abundance. In practice, *C. tritaeniorhynchus* abundance during 1994 was greater than in other years observed, and the same relationship was held true for the number of engorged mosquitoes collected during those years. However, monthly engorgement success was not always linked to overall mosquito abundance. In 1992, *A. sinensis* was most abundant in July, but engorgement of females has the highest rate in June. Basiced on the data previously reported and also our own, it is highly likaly that blood feeding was significantly associated with the rainfall, wind and humidity, *etc.* Indeed, Day and Curtis[20] reported that *C. nigripalpus* abundance and blood feeding behaviour was closely tied with daily rainfall patterns. Similar results on vector mosquitoes have also been obtained by Lee *et al.*[7], Provost[21], Olson *et al.*[22], and Russel[23].

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