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Seasonal Prevalence and Abundance of Mosquitoes at the Busan Port (2001~2006)

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The purpose of this study is to examine the population density of the mosquito species, and to provide the basic data related to vector mosquitoes to manage the possible epidemic diseases. During a 4-year investigation (2001, 2002, 2004, and 2006), we collected the specimens of the mosquitoes at pier no. 1, 3 and 5 of Busan port with light traps from sunset until the next day morning from April to October each year. Through the research, we collected 5,985 mosquito specimens in total and found 7 mosquito species belonging to 3 genera. A total of 1,575, 1,473, 1,478 and 1,459 mosquito specimens were collected in 2001, 2002, 2004 and 2006, respectively. Among them, 5,568 (93.0%) specimens were *Culex pipiens pallens*, the West Nile virus infection vector, which showed the highest density among the specimens. The population densities of the other species were: 295(4.9%) *Culex tritaeniorhynchus*, 94(1.5%) *Aedes togoi*, 12(0.3%) *Aedes albopictus*, 10(0.2%) *Anopheles sinensis*, 4(0.1%) *Aedes vexans nipponii*, 2(0.1%) *Culex inatomii*. The monthly abundance of mosquitoes from July through September showed the highest values. Although it was a general mosquito monitoring study, this study could provide a base for securing the statistical data on spreading epidemic diseases by people infected outside Korea.

Key Words : Light trap, Population density, Mosquitoes, Busan port, Epidemic disease

Introduction

The mosquitoes are the vector of West Nile virus infection, Dengue fever, yellow fever, Japanese encephalitis, Brugia malayi, and Malaria (Park *et al*, 1971; Turell *et al*, 2000; Kunkel *et al*, 2006).

Among these diseases, West Nile virus infection and Malaria are considered to have occurred with highest frequency lately (Ishida *et al*, 2003; Benoit and Denlinger, 2007; Anderson *et al*, 2004; Shin *et al*, 1976; Lee and Kim, 2001). West Nile virus infection has entered eastern part of United States in 1999, spread to entire United States and Canada during 2000, 2001, and 2002 (Anderson *et al*, 2004; Meece *et al*, 2003). Recently there have been more than 35,000 cases and 200 death due to WNV in North America and many more in rest of the world (Vinayagamoorthy *et al*, 2005). The vectors that are found within Korea are *Culex pipiens pallens*, *Aedes vexans nipponii*, and *Aedes albopictus*.

Malaria is often called 'the worst disease on earth', considered the most important disease of the world and 4 billions of 100 nations live within Malaria-occurring areas (Ndao *et al*, 2004; Palmer *et al*, 2003) ; furthermore, at least 3 billions of patients are infected with malaria and 1.5~2.0 millions of the patients die each year (Johnston *et al*, 2006;

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Iqbal *et al*, 1999). From 2001 to 2004 there have been 6,426 cases of epidemic diseases and 6,328 cases were of Malaria. Lately Malaria has been occurring within specific region in Korea that it could become an endemic disease of the area (Park *et al*, 2000; Ki and Kim, 2005; Ree *et al*, 2005).

The best way to avoid the diseases is not getting bit by the mosquitoes and constantly monitoring the carrier mosquitoes. Mosquitoes show specificity of different diseases for different species and each effect is unique. Since seasonal fluctuations, kinds, and the dominant species of the mosquitoes change, it is important to be aware of the areas in which the malaria is likely to occur frequently (Kawamoto *et al*, 1996; Kim *et al*, 1999; Jeong and Lee, 2003; Ree, 2003; Kim *et al*, 2006; Hwang *et al*, 2006).

Until now, the studies on the mosquitoes have been limited to the mosquito species found within Korea and those that carry the diseases. However, the transportation and trade between nations have developed and are more frequent, the problem of importing foreign mosquito species deepened. As a result, new diseases might become endemic. Because the vectors live in Korea as well, we can't be sure when the disease enters Korea; therefore, monitoring the mosquitoes through investigation is necessary (Kim *et al*, 2005; Kim *et al*, 2006).

Busan port is the major place where the import and export occur freely, therefore there is a high risk that vectors including mosquitoes can enter Korea (Lee and Kim, 2001). During 4 years, Mosquitoes density survey in 3 selected Busan ports from April to October, once a week from sunset to next day. After finding out whether the foreign mosquito species has entered Korea or not through investigation of the mosquitoes within the port area, if there is a problem with the disease related to mosquitoes, this study is to provide basic information to handle such situation.

Materials and Methods

Busan port is the largest port of Korea where 22.9% of worldwide ships dock; therefore, the most of foreign materials as well as foreign people enter through this port. Since the object of the study is not only to study mosquito's density fluctuation but also to check whether the foreign mosquitoes entered Korea or not, Busan port was the perfect place for the investigation. We selected borderline of the coast as the investigating area and selected pier 1 (GPS. N 35°6′24.06″, E 129°2′57.29″), where the arrival and the departure of the international passenger ship is frequent, pier 3 (GPS. N 35°6′39.99″, E 129°3′35.71″), where the container ships that go to China and Japan dock, and pier 5 (GPS. N 35°7′9.36″, E 129°3′25.85″), where container ships that go to Europe dock as collecting area (Fig. 1).

During 4 years (2001, 2002, 2004, 2006), we have collected mosquitoes. Because of the effects of weather such as typhoon, there were not many specimens collected in 2003 and 2005. So the results from those years are excluded. Three selected regions from April to October, once a

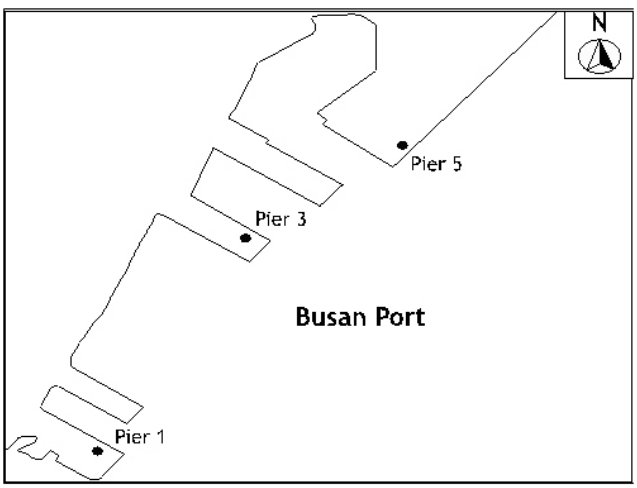

Fig 1. A map showing the three mosquitoes collection sites in Busan port.
* Pier 1 : GPS. N35 ° 6′24.06″, E129 ° 2′57.29″
* Pier 3 : GPS. N 35 ° 6′39.99″, E129 ° 3′35.71″
* Pier 5 :GPS. N35 ° 7′9.36″, E129 ° 3′25.85″

week from sunset to next day. To collect the mosquitoes, Nozawa light traps, which are 1.5~2 m high, under a tent where it could avoid rain or open building, and dry ice is put 10cm above black light in order to attract mosquitoes; as the carbon dioxide from dry ice settle down, it lures mosquitoes to the light traps. Collected specimens are carried carefully to the lab, where they are frozen, and then dried for 1~2 days. From the specimens, we selected only mosquitoes and classified based on year, month, and the collecting area using stereomicroscope.

Results

Total 5,985 specimens were collected during 4 years. The collected specimens were consisted of 7 species in 3 genera. From start of the collection date to the October, *C. pipiens pallens* was the most abundant species among the collected samples of each species. The most collected species are *C. pipiens pallens*, the West Nile virus vector, which makes up 5,568 (93.0%) mosquitoes of all specimens. 295 (4.9%) of specimens were the Japanese encephalitis vector *Culex tritaeniorhynchus*, and 94 (1.6%) of specimens were the Brugia malayi vector *Aedes togoi*. 0.2% of the specimens were the Dengue fever vector, *A. albopictus* showed 0.2% and 0.16% were the malaria vector, *Anopheles sinensis*. Lastly *A. vexans nipponii* and *C. inatomii* each showed 0.07% and 0.03% among the specimens. Looking at the monthly abundance of mosquitoes density, those from July through September showed highest values. In October, the collected number of *C. pipiens pallens* was still at the high value suggesting that the number of the mosquitoes did not decrease because of the late summer heat. 70% (7 out of 10 specimens) of malaria vector *A. sinensis* were collected during July (Table 1).

The number of mosquitoes in 2001 was the biggest number that is 1,575, whereas distribution of them in 2002, 2004, and 2006 was nearly similar. The average number of *C. pipiens pallens* was 1,402, which has been the highest distribution rate since we studied density of mosquitoes. Distribution of *C. tritaeniorhynchus* showed 12.5% (195 specimens) in 2001, which is much higher than 2.0% (30 specimens) in 2002, 3.2% (47 specimens) in 2004, and 0.3% (5 specimens) in 2006. *C. inatomii* were collected only each 1 mosquitoes in 2002 and 2004, *A. vexans nipponii* were collected 4 mosquitoes in 2001 and 2002. *A. togoi* looked regular distribution through all period that we collected mosquitoes, *A. albopictus* were not collected in 2002. *A. sinensis* were first 0.3% (5 specimens) in 2001, however, they decreased gradually through 2002 and 2004, finally it was not found in 2006 (Table 2).

The collecting areas were pier 1 where the arrival and

Table 1. Cumulative number of mosquitoes captured in Busan port in years

Species	No. of mosquitoes							
	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Culex pipiens pallens	4	189	915	1,436	1,158	1,535	331	5,568
Culex tritaeniorhynchus	–	–	–	21	114	144	16	295
Culex inatomii	–	–	–	2	–	–	–	2
Aedes togoi	–	3	9	38	32	11	1	94
Aedes albopictus	–	–	1	3	2	5	1	12
Aedes vexans nipponii	–	–	2	–	2	–	–	4
Anopheles sinensis	–	–	1	7	1	1	–	10
Total	**4**	**192**	**928**	**1,507**	**1,307**	**1,696**	**349**	**5,985**

Table 2. Mean number and species ratio per trap night in each year of female mosquitoes collected from light trap in Busan port

Species	2001	2002	2004	2006	Total
Culex pipiens pallens	1,359	1,408	1,410	1,430	5,568
Culex tritaeniorhynchus	195	30	47	5	295
Culex inatomii	–	1	1	–	2
Aedes togoi	12	28	17	20	94
Aedes albopictus	2	–	2	4	12
Aedes vexans nipponii	2	2	–	–	4
Anopheles sinensis	5	4	1	–	10
Total	**1,575**	**1,473**	**1,478**	**1,459**	**5,985**

※ We excluded values from 2003 and 2005 since the number of collected samples was not enough from the effect of the typhoon.

the departure of the international passenger ship is frequent, pier 3 where the container ships which go to China and Japan dock, and pier 5 where container ships that go to Europe dock. 2,106 mosquitoes of 6 species were collected in pier 1. Most of the specimens (2,404 specimens) were collected in pier 5 and the lowest number of specimens was 1,475 in pier 3 which is pier of the container ships from Japan and China. The unique case about pier 3 is that the total number of specimens collected in the port is relatively small, because the place where the light trap that was set up, was open space with frequent wind. Furthermore, there were less people entering the area. When specimens were analyzed, *C. pipiens pallens* had the highest density at all collecting areas. *C. tritaeniorhynchus* had the highest density as 216 specimens in pier 5, on the other hand, pier 1 and pier 3 had 55 specimens and 23 specimens. Specimens of *C. inatomii* were not collected in 1 and 3 pier as well as just 2 mosquitoes in pier 5. *A. togoi* showed regular distribution as 23~42 mosquitoes in three piers. 7 species were collected during the investigation in pier 5 which distribution of mosquitoes is the most densely region, 7 specimens were *A. albopictus*, 3 specimens were *A. vexans nipponii* and 6 specimens were *A. sinensis*. *A. sinensis*, the *P. vivax malaria* was most collected in pier 5, July. In pier 1 and 3, specimens of *C. inatomii* and *A. vexans nipponii* were not collected and in pier 3 (Table 3).

Table 3. Cumulative number of mosquitoes captured from three collections sites in Busan port years 2001, 2002, 2004 and 2006

Species	No. of mosquitoes			
	pier 1	pier 3	pier 5	Total
Culex pipiens pallens	2,020	1,420	2128	5,568
Culex tritaeniorhynchus	55	23	216	294
Culex inatomii	–	–	2	2
Aedes togoi	23	29	42	94
Aedes albopictus	5	1	7	13
Aedes vexans nipponii	1	–	3	4
Anopheles sinensis	2	2	6	10
Total	**2,106**	**1,475**	**2,402**	**5,985**

Discussion

Investigation of the density of the mosquitoes within the inspection area is a valuable data for preventing the epidemic diseases carried by mosquitoes. Busan port is the major center of import and export; therefore, there is a high possibility that the vectors of the epidemic diseases such as mosquitoes can influx into Korea. This study inves-

tigates whether the foreign mosquitoes has entered Korea or not by studying the density of the species of the mosquitoes, and provides the basic data to manage the possible epidemic related to the mosquitoes.

During the investigation from 2001 to 2006, we collected the specimens of the mosquitoes with light traps at pier 1, 3 and 5 of Busan port from April to October, from sunset until the next day. The density of the mosquitoes is at the highest level from July to September. The species of the mosquitoes confirmed by this study are *C. pipiens pallens*, *C. tritaeniohynchus*, .*C. inatomii*, *A. togoi*, *A. albopictus*, *A. vexans nipponii*, and *A. sinensis*, 7 species in 3 genera. Total 5,985 specimens were collected, and 93.0% of the specimens were *C. pipiens pallens*, the West Nile virus infection vector, which showed the highest density among the specimens. 4.9% of the specimens were the Japanese encephalitis vector, *C. tritaeniohynchus*. 1.5% of the specimens were the Brugia malayi vector, *A. togoi*, and 0.3% of the specimens were the Dangue fever vector, *A. albopictus*. 0.2% were the Malaria vector, *A. sinensis*. Lastly *A. vexans nipponii* and *C. inatomii* each showed 0.1% among the specimens. Dengue fever has not been reported in Korea, but there are several cases where people were infected with Dengue fever outside Korea and came back.

In this study, the mosquito species that carries an epidemic disease that is fatal to one's health was not found, and collected mosquito specimens were relatively simple with low density because areas around Busan port has been already urbanized. However, there was a case in a hospital in Busan where a patient who never visited other country died of Malaria (*Plasmodium falcifarum*), which shows the need of continuos studies such as this one in order to find out whether the foreign vectors have entered Korea or not.

It is impossible to analyze everything with the data we got from this study, but if the investigation is continuously performed, we could confirm not only the statistics of the appearance of the mosquitoes but also the influx of the foreign vectors. This study is a general monitoring, but the study including analysis of the foreign mosquito species, comparison of base sequencing as well as statistical group analysis of virus registered in Gen Bank, and securing the statistic data of spreading epidemic diseases by people infected outside Korea must be performed in the future.

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