Surveillance and Control for *Anopheles sinensis* Wiedemann at Taichung Airport

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Abstract

Anopheles sinensis Wiedemann was not considered as important as *An. minimus* Theobald in spreading of malaria in Taiwan, but it is the main vector of *Plasmodium vivax* in China and South Korea. In mid-June 2013, the Central Regional Center District of Taiwan CDC at international terminal of Taichung Airport found female mosquitoes of *An. sinensis* attempting to suck blood the first time. In order to clarify the original source of mosquito, we reviewed the past surveys, conducted breeding–site survey and outdoor night time survey with light traps. One adult male mosquito of *An. sinensis* was captured at the fence between airport and the factory of Aerospace Industrial Development Corporation (AIDC) and found one sand basin with larvae bred.

With no blood source in sand basin, *An. sinensis* was phototaxis and attracted by the Apron floodlighting illuminated at night, and no air doors at the entrance, there was high risk for *An. sinensis* to follow human indoors. Also, there was a record of finding *Culex Quinquefasciatus* Say in aircrafts from dengue epidemic areas by sweeping. However, there was no flight route from/to malaria epidemic areas at Taichung airport and no malaria outbreak either in past year, so it had low possibility that the mosquito was introduced by aircrafts.

Since there was low density of adult *An. sinensis* in indoors and outdoors of terminals, we did not spray insecticides. Considering that drainage of sand basin might flow into irrigation canals and affect the environment, the biological control management, using larvivorous fish, *Macropodus opercularis* Ahl to decrease density of larvae. After one week, we did not find larvae and adult mosquito of *An. sinensis* and other mosquito species. Up to the end of September 2013, the surveillance of indoors and outdoors in Taichung Airport didn't discover larvae and adult mosquitoes of *An. sinensis* anymore.

It is recommended that surveying port mosquitoes should be collected simultaneously the local indoor and outdoor mosquito species, in order to establish basic information as reference to determine whether alien species mosquito appeared or not.

Keywords: Port mosquito surveillance, *Anopheles sinensis* Wiedemann, *Macropodus opercularis* Ahl

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Introduction

In order to prevent transmission of infectious diseases and ensure no epidemic in this country, Taiwan Centers for Disease Control (Taiwan CDC) set up quarantine at international ports (airport or harbor) and vector surveillance in accordance with "Communicable Disease Control Act" and "Regulations Governing Quarantine at Ports". The Central Regional Center of Taiwan CDC applied vector surveillance in Taichung Airport, including several common vector borne diseases, such as Dengue fever, Chikungunya fever, West Nile virus, Japanese encephalitis and Malaria.

Taichung Airport is in Shalu district, Taichung City. It is a joint-use (civilian/military) airport and relocated from Shueinan Airport to Ching Chuan Kang Air Base (CCK) in 2004. The initial stage after relocation, Taichung Airport operated domestic flights and international non-scheduled charter flights, and it has one terminal and one runway which shared with CCK. In 2009, Taiwan and China signed the "Cross-Strait Air Transportation Agreement" [1], and Taichung Airport was included in one of the charter waypoints. Since China cities have direct flights to Taiwan, the international flights and the cross-strait flights in Taichung Airport traffic surged. Since Taiwanese businessmen who live in central Taiwan have a great demand for international airlines, Civil Aeronautics Administration, Ministry of Transportation and Communications spent NT$ 3.9 billion on the expansion project of Taichung Airport in 2011, and the new International Terminal opened on April 11, 2013. Its main airlines including Hong Kong, Macao and China cities with direct routes, and the others are Southeast Asia (Vietnam) and Northeast Asia (Japan) [2].

Among the 17 species of Anopheles identified by scholars in Taiwan, *An. minimus* is considered the main vector of malaria in Taiwan, but it is in doubt that if *An. kochi* Dönitz and *An. fluviatilis* James breed in Taiwan. As regard to *An. sinensis*, it was only a mistake when some trypanosome were recognized as *Plasmodium* sporozoites [3]. Nevertheless, early studies discovered that *An. sinensis* was susceptible to *P. vivax* and *P. malariae* [4]. In 2013, Chinese studied the sensibility of *An. sinensis* to *P. vivax* by membrane feeding assay. They found out that there was no difference between the infection ability of *An. sinensis* and *An. anthropophagus* Xu and Feng, and these two species were the main vector of *P. vivax* in central areas of China in 2005 [5]. It was proved that *An. sinensis* was also the main vector of *P. vivax* in Korea [6], so the risk by *An. sinensis* still could not be ignored.

An. sinensis distributed widely in Asia, from Afghanistan to northern China, Japan, Korea, Taiwan and to Indonesia (Sumatra and West Kalimantan) [7]. Its life cycle was 2-3 weeks at 27.5℃ with 75% relative humidity, the egg stage lasts two days, the larval stage ten, and pupal two. Larvae could breed in a variety of clean water or running water, and rice field was the main breeding sites. *An. sinensis* can be seen all year round, but they have two growth peaks, from February to March and September to October; their density related to the rice [8]. Adult mosquitoes begin to bite human and animals from dusk to dawn, the biting peak is midnight. The previous studies on the biting subjects and habitat of Anopheles in Taiwan considered they were exophilic and zoophilic [4]. Recently, the related studies still showed the same results. Chang et al., captured *An. sinensis* from outdoor and the areas near breeding site of larvae; they tested the source of breeding blood by PCR and found out that there was no human blood, 86.4% pig blood, 9.1% cattle blood and 4.5% horse blood [9]. Staining test was conducted to test the flight range of *An. sinensis*, the results showed the maximum flight distance was 550 meters [4].

In mid-June 2013, Central Regional Center of Taiwan CDC found the female *An. sinensis* which attempted to bite in International Terminal of Taichung Airport. In order to know where it comes from, we did a retrospective analysis on past survey data in Taichung airport, vector surveillance and density control of mosquitoes. All results would provide epidemic prevention units for port mosquito surveillance and control.

Materials and Methods

Scope of vector surveillance

Taichung Airport located at 24 degrees 15 seconds north latitude, longitude 120 degrees 37 seconds east, 202 meters above sea level and is 10,054 square meters in area. The main scope of mosquito surveillance was conducted in Domestic Terminal during Jan. 2001 to Apr. 2003 (The main building of the Terminal is 120 meters wide). The International Terminal was added to the project from May since it was officially opened on April 11, 2013 (The main building of the International Terminal is 255 meters wide). Mosquito survey tools were set in the place where personnel accessed frequently. The surveillance site is shown in Figure 1 by using Google Earth software version 7.1.1.1888 (Google Inc.).

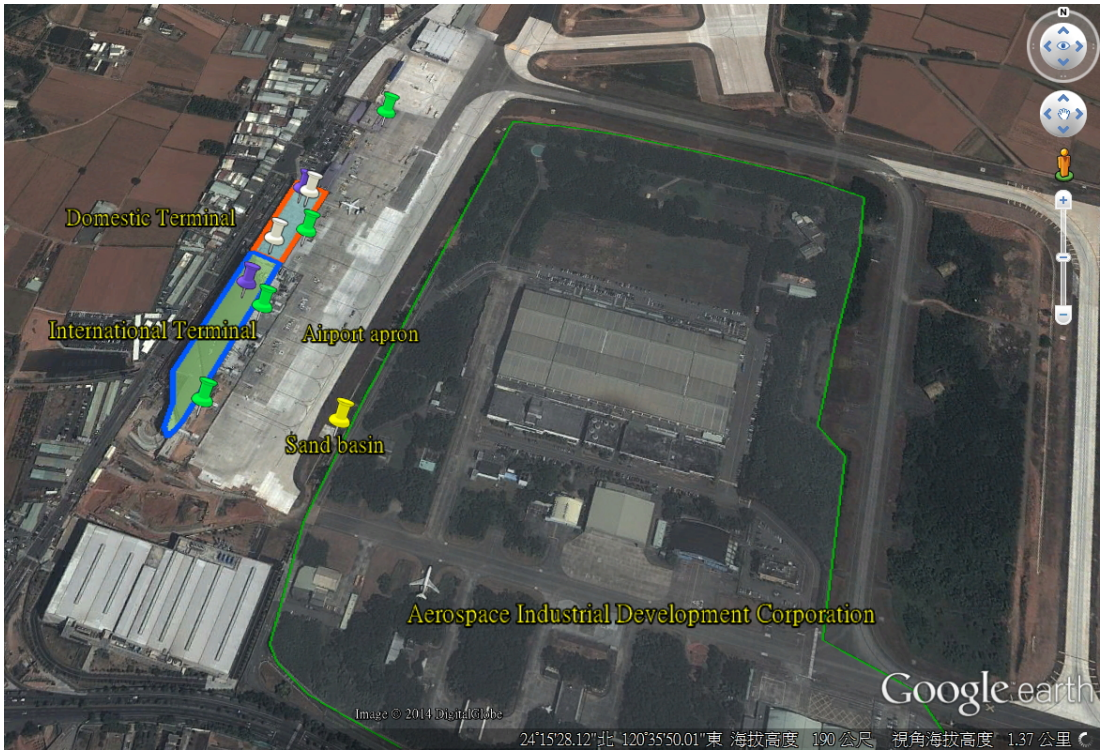

Figure 1. Map of vector surveillance sites at Taichung Airport.

Note: 1. White anchor points are surveillance sites of Domestic Terminal from January 2011 to April 2013
2. Purple anchor points are surveillance sites of Domestic and International Terminal from May 2013
3. Yellow anchor points are surveillance sites of sand basin
4. Green anchor points are surveillance sites of Airport apron

Vector surveillance before the opening of the International Terminal

Surveillance of adult mosquitoes

BG-Sentinel mosquito trap (BG- trap; Biogents AG, Regensburg, Germany) was used to investigate the density of adult mosquitoes. Surveillance was executed once a month for three consecutive days from January 2011 to April 2013. There were two locations investigated in the Domestic Terminal. Sweeping for mosquitoes was also conducted randomly in aircrafts to the inbound flights (Vietnam) from dengue endemic areas since January 2013.

Surveillance of mosquito larvae

Four ovitraps were used to survey larvae density and placed in indoors and outdoors of Domestic Terminal, separately. The container attached with nonwoven fabric and water was filled in with 5ppm Temephos (Temephos 1.0% w/w Sand Granules; Antimos, Aerolead International Ltd Taiwan) added and checked for 1-2 times in a month.

Vector surveillance after the opening of the International Terminal

Surveillance of adult mosquitoes

BG traps were used. Besides the Domestic Terminal, indoors of the International Terminal were added to the project for adult density survey since May2013. While *An. sinensis* was captured in mid-June of 2013, considering its biological characters as exophilic mosquito species and the activity peak was from the evening until midnight, PO-lite light trap (Pest-O-Lite light trap; Taiwan) was chosen to conduct surveillance at the outdoors of the Terminal.

Because the adult mosquito surveillance was emphasized at the outdoors of the Terminal in the past, so the environmental monitoring was added to the project since July 2013. The PO-lite light trap needs power supply, the Central Regional Center District of Taiwan CDC overcome the difficulties to use this type of light traps on the tarmac with electrical socket supplied. UD black light traps (Model 1312, John W. Hock Company, Gainesville, FL) with accumulator cell were used at the place without power supply. BG- traps were used inside the Terminal with odor attractants and dry ice (carbon dioxide is released) to increase the effect of luring.

Surveillance of mosquito larvae

After the International Terminal opening, we continued the surveillance with ovitraps. As the *An. sinensis* was captured, considering its larvae were generally bred in clean, unpolluted water like rice fields, irrigation ditches and streams, suspicious breeding sites were searched with ladle to collect and identify them in the airport.

Mosquito species identification

After the adult or larvae of mosquitoes were collected and preliminary identification was executed by Central Regional Center District of Taiwan CDC, the specimens were sent with cold storage to the Mosquito Lab of the Center for Research, Diagnostic and Vaccine Department, Taiwan CDC for final identification.

Results

Vector surveillance before the opening of the International Terminal

Surveillance of adult mosquitoes

The results of indoors surveillance for adult mosquitoes at the Domestic Terminal of Taichung Airport from January 2011 to April 2013 were shown in Table 1. Three species of mosquitoes: *Aedes albopictus* Skuse, *Culex pipiens* form *molestus* Forskal, and *Cx. quinquefasciatus* were captured in 2011; the latter had the most quantities.

Compared with year 2011, the species of mosquitoes captured in 2012 discovered another four species: *Ae. Aegypti* Linnaeus, *Armigeres subalbatus* Coquillett, *Cx. sitiens* Wiedemann, and *Cx. tritaeniorhynchus* Giles, but not *Cx. pipiens*. And the most number captured was still *Cx. quinquefasciatus*. *Cx. quinquefasciatus* was the only one captured from January to April in 2013. Especially, BG- trap had caught one female *Ae. aegypti* in August 2012 which was not present before in middle Taiwan. So we increased the quantity of BG- traps and ovitraps to increase the frequency of checking the egg of *Ae. aegypti* in nonwoven fabric for one month, but no egg or larva was found. By the end of September 2013, no adult mosquito of *Ae. Aegypti* was captured. There were total138 sorties in aircraft sweeping for mosquito from January to September 2013, but only one female *Cx. quinquefasciatus* was captured in February.

Table 1. Results of indoors surveillance for adult mosquitoes at the Domestic Terminal of Taichung Airport from January 2011 to April 2013[a]

Species/Year	2011	2012	2013(Jan.-Apr.)
Aedes aegypti (♀)		1	
Aedes albopictus (♀)	4	3	
Aedes albopictus (♂)		2	
Armigeres subalbatus (♀)		1	
Culex pipiens molestus (♀)	5		
Culex quinquefasciatus (♀)	97	187	10[b]
Culex quinquefasciatus (♂)	40	60	5
Culex sitiens (♀)		1	
Culex tritaeniorhynchus (♀)		5	

[a] To survey the density of adult mosquito by BG-Sentinel mosquito trap.
[b] One mosquito was capture by sweeping in aircraft.

Surveillance of mosquito larvae

The results of indoors and outdoors surveillance for larvae of *Aedes* at the Domestic Terminal of Taichung Airport from January 2011 to September 2013 were shown in Table 2. There were four survey sites before August 2012 but increased to eight when *Ae. aegypti* was captured. There were no larvae found in any ovitrap. After examined the egg of mosquito in nonwoven fabric, the positive ratios were from 0% to 100%. *Ae. albopictus* could be captured by sweeping around the positive ovitraps generally. There were no egg found and none adult mosquito of *Ae. aegypti* was captured at the indoors of the Terminal from December 2012 to April 2013.

Table 2. Results of indoors and outdoors surveillance for larvae of *Aedes* at the Domestic Terminal of Taichung Airport from January 2011 to September 2013[a]

Month/Year	2011		2012		2013[b]	
	Numbers of larvae	(Positive rate %)	Numbers of larvae	(Positive rate %)	Numbers of larvae	(Positive rate %)
January	4	(0)	4	(25)	8	(0)
February	4	(25)	4	(100)	8	(0)
March	4	(0)	4	(25)	8	(0)
April	4	(0)	4	(25)	8	(0)
May	4	(25)	4	(50)	11	(0)
June	4	(25)	4	(100)	11	(0)
July	4	(50)	4	(100)	11	(18.1)
August	4	(25)	20	(50)	11	(54.5)
September	4	(25)	32	(15.6)	15	(40)
October	4	(75)	8	(0)		
November	4	(25)	8	(12.5)		
December	4	(25)	8	(0)		

[a] Using ovitraps to survey the density of *Aedes* larvae.
[b] The International Terminal was opened in May, 2013.

Vector surveillance after the opening of the International Terminal

Surveillance of adult mosquitoes

The results of surveillance for adult mosquito in Taichung Airport from May to September 2013 were shown in Table 3. There was no mosquito captured at two survey sites at the Domestic and International Terminal in May 2013. The female of *An. sinensis* were captured by bare hand and sweeping at the indoors of International Terminal on June 13 and 14 separately. Morphological identification of these two mosquitoes of *An. sinensis* [10] revealed that the color of legs were dark, all tarsus had light-color bands, and the front edge of wing veins had two light-spots. At the same time, *Culex* spp. were captured by BG- trap only at the indoors in the International Terminal among two survey sites (number of mosquito captured: 13 female and 2 male and not recorded in Table 3 because the species without identification). One male of *An. sinensis* was captured by PO-Lite light trap in the night time survey at the fence between airport and the factory of AIDC on 20th June after the first *An. sinensis* was captured one week later. Male mosquito lives near the breeding place after emerge, so we found a sand basin (length: 15meter, width: 15meter, depth: 30meter, about 160-meter away from the International Terminal) 10-meter away from the location of the PO-Lite light trap. Again, we surveyed the sand basin with PO-Lite light trap and captured *An. sinensis* (1 male and 1 female) and *Culex* spp. (5 female and 8 male, without identification) on 26th June.

Cx. pipiens form *molestus* and *Cx. quinquefasciatus* were both captured at indoors in the Domestic and International Terminal from July to September 2013. The reason why the number of *Cx. quinquefasciatus* captured in the Domestic Terminal was larger than in the International Terminal might be associated with the increasing number of dry ice used in BG- trap. *Cx. pipiens* form *molestus* , *Cx. quinquefasciatus* , *Cx.tritaeniorhynchus* , *Ae. albopictus* and *Cx. annulus* Theobald were captured at the airport apron from July to August 2013. The greatest quantity of mosquito captured is *Cx.tritaeniorhynchus* at the outdoors environmental survey. It is worth noting that *Cx.tritaeniorhynchus* and *Cx. annulus* is the vector of Japanese encephalitis.

There were no mosquitoes captured at the sand basin in July 2013. *Ae. albopictus* , *Cx. Quinquefasciatus* and *Cx.tritaeniorhynchus* were captured from August to September, but the quantity is few. *An. sinensis* was not captured anymore from July to September 2013 both at indoors and outdoors of terminal.

Table 3. Results of surveillance for adult mosquito in Taichung Airport from May to September 2013[a]

Species	May		June			July				August				September			
	D.[b]	Int.[c]	D.	Int.	SB[e]	D.	Int.	SB	Apron[f]	D.	Int.	SB	Apron[f]	D.	Int	SB	Apron[f]
Aedes albopictus (♀)												1[g]	2			3[g]	
Anopheles sinensis (♀)				2[d]	1[f]												
Anopheles sinensis (♂)					2[f]												
Culex quinquefasciatus (♀)						133	3		2		6	2[g]	3	7	2	1[g]	
Culex quinquefasciatus (♂)						1							3	3			
Culex pipiens molestus (♀)						1			1		2						
Culex tritaeniorhynchus (♀)									4			2[g]	49			1[g]	
Culex tritaeniorhynchus (♂)									2				1				
Culex annulus (♀)													3				

[a] Since *Anopheles sinensis* was found in June 2013 at Taichung Airport, the light trap was conducted to survey the density of adult mosquitoes at the outdoors of Taichung Airport in night.
[b] D.: Survey by BG-Sentinel mosquito trap in the Domestic Terminal
[c] Int.: Survey by BG-Sentinel mosquito trap in the International Terminal
[d] Mosquitoes were capture by hands and sweeping.
[e] SB: Sand Basin
[f] Survey by PO-lite light trap.
[g] Survey by updraft black light trap.

Surveillance of mosquito larvae

As the International Terminal officially opened, the number of surveillance sites with ovitraps had increased to 11 since May and up to 15 at September 2013. The results of the larvae surveillance were shown in Table 2. Eggs of *Ae. albopictus* were recorded but no larva was found from July to September in the ovitrap. Five larvae of *An. sinensis* were captured in the sand basin water by using soup ladles at the survey project. The Central Regional Center District of Taiwan CDC had released ten and twenty larvivorous fishes, *M. opercularis* on 1st and 8th July separately, in order to prevent the larvae of *An. sinensis* from breeding at the sand basin. Because there is no larva of *An.sinensis* was captured, showed that *M. opercularis* is very effective to control the mosquitoes. At the same time, we tried to find out other possible breeding sites (like rice fields, streams or irrigation ditches) for *An. sinensis* larva at airport and CCK, but the result was zero.

Risk assessment and control recommendations of malaria transmission

After the breeding sites of *An. sinensis* were discovered at the airport, Central Regional Center of Taiwan CDC had invited the Center for Research, Diagnostic and Vaccine Department Taiwan to conduct habitat survey and risk assessment of the malaria transmission and provide recommendations on July 1.

A. *An. sinensis* is not the main vector of malaria in Taiwan, but in China and Korea it does. Two female of *An. sinensis* at indoors in the terminal were captured. Alert us that when a passenger who contracted Malaria and arrived from Taichung Airport, if bitten by *An. sinensis* and might be infected with *plasmodium*, without any other blood source around, it might cause local malaria outbreak. Because there were breeding sites around the airport, it was necessary to set up air doors at the entrance of the international terminal to control the vectors.
B. The larvae of *An. sinensis* and *Cx. fuscanus* were found in the sand basin and the latter was a larva eater. Considering we could not confirm whether the drainage system of the airport was inflow to irrigation ditches or not, so we carry out biological control by releasing larvivoruos fishes to eat the larvae and put gauze at drain outlet of the sand basin to prevent adult fly into it. The breeding situation of *An. sinensis* and surviving condition of larvivoruos fishes are kept monitoring.
C. Since there are water in the drains around the airfield and would become the breeding sites of mosquitoes. We recommend the gauze could be settled on the bottom of the drain cover to prevent mosquito get into the airport easily.
D. Mosquito lights trap should be hung up around the airport in order to confirm the local mosquito species and build up the basic data as a reference to evaluate the invasion species of mosquitoes.

Control Measures

After the sand basin was confirmed as a breeding site of *An. sinensis* , the Central Regional Center District of Taiwan CDC executed biological control by releasing larvivorus fishes, *M. opercularis* to eat the larvae of the mosquitoes according to the recommendation of the Center for Research, Diagnostic and Vaccine Department, Taiwan CDC and informed the result of surveillance at terminal indoors to Taichung Airport Management Units about the high density of *Cx. quinquefasciatus* . The Taichung Airport management units cleaned up the surrounding environment of the terminal instantly. In order to decline the density of *Cx. quinquefasciatus* , the Central Regional Center District of Taiwan CDC discharged the Pyriproxyfen(Sumilarv® 0.5G；Sumitomo Chemical Co., Tokyo, Japan) into the ditches and drains airside apron around the terminal on July 5 and leaving insecticide labels to the management units as a reference. The recommendation of control about settle gauze in the drain around the terminal and airfield was not accepted by the management units. The terminal management units indicated that the gauze settled around the terminal may lead to the accumulation of litter on the drain cover and cause flight safety concerns; also the gauze settled around the airfield may affect the drainage. But they would subsequently request budget increasing for installing the air door at Terminal entrance to prevent mosquitoes fly into the terminal.

Discussion

There were several possibilities about that *An. sinensis* were discovered indoors at the Terminal, one might be the local mosquito species flew into the terminal from outside, the other might be introduced by aircraft. In order to confirm the first assumption, we could conduct outdoors surveillance to identify the species exist and increase the frequency of mosquito sweeping. For the second, because the manpower of quarantine was limited and the flight route from malaria endemic area were not added after the opening of the International Terminal. Because there was no malaria outbreak at the waypoints, round-trip flight to Taichung at home and abroad during the past year, therefore, the possibility that *An. sinensis* might be carried by aircraft was really low. Fortunately, in the situation that the adult mosquito density was not high; we still could discover *An. sinensis* and its breeding sites around the terminal at the first outdoors environmental surveillance. Therefore, we assumed that *An. sinensis* might fly into the building from outdoors. There are several evidences to support such speculation. First, because of nighttime operations, the apron has five large searchlights illuminated at night. Due to the phototaxis of mosquitoes, insects (crickets, moths, grasshoppers, mantis, etc.) could be found resting at the ground floor of the Ramp and building of

International Terminal or the glasses and indoors of the terminal after the opening of the International Terminal. Second, since the flight distance of *An. sinensis* is about 550 meters and the distance between International Terminal and sand basin is about 160 meters. So, it is not difficult for *An. sinensis* to fly from the sand basin to the International Terminal. Besides, the airport staffs accessed terminal control areas through the freight elevators of apron or the stairs of the Ramp and there were no air doors at the relevant entrance. Since there were no other bloodsucking source around the sand basin, it was possible for *An. sinensis* to follow the staff and entering the buildings for blood meal. Literature showed that they had discovered the existence of a significant number of *An. sinensis* in the past at the west coast of Taiwan. As large-scale control for malaria mosquitoes with DDT (dichloro-diphenyl-trichloroethane) sprayed was focused on *An. minimus* in the past so the density of *An. sinensis* would not be eliminated as the degree of *An. minimus* or reduced close to zero. Thus presuming that *An. sinensis* was already existed at Taichung Airport but the density might be quite low.

The possibility of introducing exotic mosquito species by aircraft was not high in this event. But mosquitoes can survive on long-haul flights, travelling to and from between tropical and temperate climates and the non-native *Ae. aegypti* and *Cx. quinquefasciatus* could be found at inbound flights. These evidences proved that air transportation is an important way to promote the global movement of mosquitoes. The most classic example was that six cases of airport malaria were identified in and around Roissy-Charles-de-Gaulle Airport within 3 weeks in 1994. It is estimated that there were about 250 to 300 sorties flew from the malaria endemic areas to France. If every flight has 8-20 *Anopheles spp.*, it was estimated that there should be 2000-5000 *Anopheles* entered France. If Taichung Airport plans to increase any new waypoint that was endemic or outbreak epidemic area, the risk of introducing exotic mosquito species by aircraft from the epidemic areas should be concerned.

Because the adult mosquito density of *An. sinensis* was quite low and we did not rediscover any adult mosquitoes inside the Terminal under the subsequent surveillance, hence the chemical control (residual spraying or space spraying.) was not considered. So we focused on controlling the larvae at sand basin. The water of sand basin was from raining and drainage of apron or drainage near the AIDC would converge at sand basin then drained to further downstream. Depth of the sand basin was up to 30 cm, even lack of rain, the water depth was still 15 cm, so that was a permanent water source of larvae breeding sites. It was an impractical method to pump out the water, because there would still be some accumulated water after raining. Considering that drainage of sand basin might flow into irrigation canals and affect the environment, it was impossible to conduct chemical spray. Finally, we carry out biological control management principally.

As for the drains around terminal were less concerns about polluted irrigation ditches, so we discharge the Pyriproxyfen. The chemical insecticide is hormone analogues for insects' larvae and had the advantages of specificity to insects and non-toxic and low pollution to animals. It could interfere with the growth and development of insect larvae, so the larvae cannot emergence and attain the effect of mosquitoes control.

The release of larvivorous fishes to control mosquito larvae is one of the common methods of biological control especially in the artificial containers at the urban areas, *Anopheles* larvae is applicable too. Africa and India already had successful cases about the release of larvivorous fishes to against vectors in artificial water storage (such as wells, cisterns, buckets). In urban areas, the implementation of malaria control programs must rely on whether the residents could accept to raise larvivorous fishes in drinking water and toilet water or not, and educate to avoid killing fish accidentally. However, we do not have these concerns in the sand basin this time. Releasing larvivorous fishes (*Gambususia affinis* Baird and Girard or *Poecilia reticulate* Peters) to control mosquito larvae has years of history. Both fishes were belonged to the alien species, *P. reticulate* did not pose a threat against native species in Taiwan, but *G. affinis* not only eat mosquito larvae but also eat other types of juvenile fishes, and it would affect the ecology. Fortunately, some researchers discovered other kinds of Taiwanese larvivorous fishes, *M. opercularis* had some adaptability to environment about a greater amount of predation and resistant to hunger, chlorine, temperature and insecticide compared with the previous two larvivorous fishes. Thus, it had a high potential for dengue vector control of *Aedes* larvae. And we had good experience about releasing *M. opercularis* to control *An. sinensis* larvae. It rained for several days and had a high rainfall at Taichung Airport in late July. While the water level of sand basin rose, the larvivorous fish left the sand basin with drainage. When we surveyed the sand basin in August, the fish disappeared because of the drainage. So continue releasing larvivorous fishes and observing its survival situation is an important issue which we must pay attention to biological control.

Conclusion

After active surveillances at outdoors environment of the airports, we discovered breeding sites of *An. sinensis* around the airport. We could reasonably assume that *An. sinensis* would fly into the International Terminal from outdoors environment with some reasons. First, there was no other bloodsucking source for *An. sinensis* and the breeding sites are not far from the terminal. Second, adult mosquitoes are biological phototaxis and need reproduction. Because we focused on indoors mosquito species distribution during surveillance period, if any other special species were discovered,

it would be a problem for the subsequent control method. It is recommended that surveying port mosquitoes should collect both indoors and outdoors local mosquito species simultaneously in order to establish basic information as a reference to determine whether imported species exist or not.

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