

# Mosquito Surveillance (Diptera: Culicidae) From Underground Parking Lots in Urban Area in Wuhan, Central China

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## Abstract

Due to urban development and underground parking lot increase, mosquito habitats in 42 urban underground parking lots (UPLs) in densely populated metropolitan areas (Jiang'an and Jiangnan districts), Wuhan, central China have been investigated from August to October 2012. Out of the 42 locations 14 were served for business properties and institutions (BPI) and 28 served for property management residential areas (PMRA). Five representative potential habitats were sampled and immature mosquitoes were founded from 40 (95%) UPLs, included 12 (86%) UPLs from BPI and 28 UPLs from PMRA. The percentages of UPLs with the collections of *Culex pipiens quinquefasciatus* Say, *Culex pipiens molestus* and *Aedes albopitius* Skuse were 88%, 36% and 60%, respectively. Immature mosquitoes were collected from 118 out of the 204 standing water habitats sampled (58%). The most abundant positive habitats were cisterns (n=83), followed by ditches (n=29). The proportion of mosquito positive habitats was significantly higher in UPLs for PMRA (64%) than for BPI (46%). Building UPLs in populous areas of city leads to mosquito breeding and may increase the risk of mosquito borne diseases. This study suggests that local mosquito control programs in developmental and high density cities should focus on the surveillance and control of the breeding sites in UPLs.

**Keywords:** Underground parking lots; Mosquito habitat; *Culex pipiens* complex; *Aedes albopitius*

## Introduction

The increasing population and economic development of urban Wuhan and central China led to increased demand for motor vehicles. Total number of motor vehicles in Wuhan has increased from 60,000 in 1986 to 1,300,000 in 2012. To reduce traffic congestion and save urban land, more and more underground parking lots (UPLs) have been built by both private and public agencies. The concrete water storage cisterns and ditches in UPLs have created more suitable breeding sites for mosquitoes. Yu et al. installed ovitraps in UPLs in urban Guangzhou, 62.07% of them captured adult mosquitoes, of which 80.17% were *Aedes albopitius* Skuse [1]. Bao et al. reported that *Ae. albopitius* is a major species of container-inhabiting mosquitoes in Wuhan [2]. In 1945 there was a dengue fever outbreak in Wuhan with cases concentrated in the heavily populated area of Hankou [3], which included Jiang'an, Jiangnan, and Qiaokou Districts. About 80% of Hankou residents were infected with dengue virus [4]. Although there has not been a local acquired dengue case since 1945, imported dengue cases have been reported in Wuhan since 2004 [5]. Other species of mosquitoes, *Culex pipiens quinquefasciatus* Say and *Culex pipiens molestus* have been also founded from habitats of UPLs [6]. The rapid increase of UPLs in heavily populated areas of Wuhan raises concern about mosquito borne diseases, such as dengue fever and chikungunya.

## Materials and Methods

Jiang'an and Jiangnan District was divided into two sections for this study. One section had twenty-two UPLs and the other had twenty. All sites were easily accessible and collaborative in Jiang'an and Jiangnan District. A total of 42 UPLs were used for this study. Out of the 42 sites, 14 served for business properties and institutions (BPI) and 28 served for property management residential areas (PMRA). There were 31 one story tall UPLs, 10 two story tall UPLs and 1 three story tall UPL. All UPLs were built during the period of 1994-2010 however; the majority has been built during 2005-2012.

Usually there were ditches built on the ground of the entrance or

exit tunnel and on the ground of each floor. The majority of the ditches had grating covers, but there were some ditches that did not in this study. Water storage cisterns were usually built on the deepest storey of a two or three-story UPL. On the other hand, some were located on the upper story. In most cases, an automatic submersible pump was installed above the bottom of each cistern, which resulted in stagnant water in the cisterns. Both highly organic and clear water was noticed in the cisterns. Mosquitoes were accessed in the cistern water either through the openings on the cover or through the lateral ditches.

A survey of stagnant water for immature mosquitoes (larvae and pupae) was undertaken in each of the UPLs, from August to October in 2012. Habitats were classified as one of the five sites: cisterns, ditches, small containers, shallow waters (irregular shape water deeper than 2 cm and usually shallower than 8 cm on the ground), discarded car tires and others.

During each sampling occasion a visual observation was used initially to determine if there were any immature mosquitoes. Each habitat was sampled using a dip (500 ml) hand net or a pipette and recorded. Twenty - 400 immature mosquito samples based on the immature mosquito density in each breeding site were placed in an airtight 3.2 liter plastic box for each UPL, labeled, and sent to the vector laboratory. Larvae were reared with brewers' yeast. Late instar *Ae. albopitius* larvae were identified quickly. Late instar *Culex* larvae and pupae for each UPL were taken to a mosquito cage and allowed

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to emerge. Adult mosquitoes were reared at least 10 days, with rearing water placed in the cage, to observe autogenous oviposition. *Cx. p. molestus* was identified when autogenous egg-rafts were observed or adult mosquitoes morphologically identical to *Cx. p. molestus* were found in the cage. Other adult mosquitoes were identified morphologically to species.

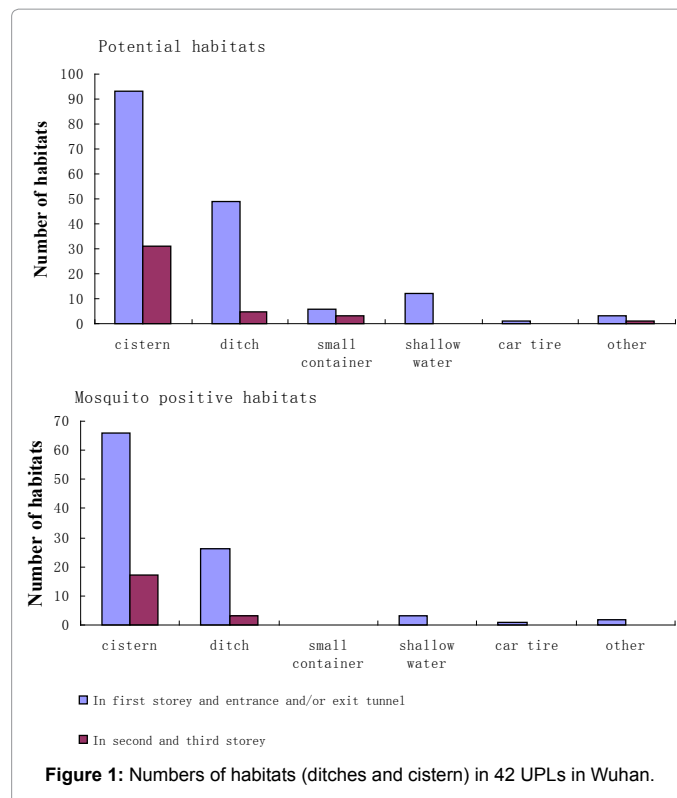
## Results and Discussion

Mosquitoes were collected from 40 out of the 42 UPLs sampled (95%). Immature mosquitoes were found from 12 (86%) UPLs for BPI, and in all the 28 UPLs for PMRA, the difference was statistically significant ( $\chi^2=4.20$ ,  $df=1$ ,  $P<0.05$ ). *Cx. p. quinquefasciatus* was found in 37 UPLs (88% of all UPLs sampled), in which 11 (79%) were UPLs for BPI, 26 (93%) were UPLs for PMRA. *Culex* mosquitoes in 11 cages each from a UPL produced autogenous eggs, and there were adults identified as *Cx. p. molestus* in each cage. Totally 15 (36%) UPLs were found with *Cx. p. molestus*. *Ae. albopitius* was found in 25 UPLs (60% of all sites sampled). The percentage of UPLs infested with *Ae. albopitius* was significantly higher in PMRA (71%), compared to BPI (36%) ( $\chi^2=4.20$ ,  $df=1$ ,  $P<0.05$ ) (Table 1).

Among these 42 UPLs, 204 standing water habitats were sampled and immature mosquitoes were found from 118 habitats (58%). In the first floor and entrance and/or exit of the UPLs, 164 potential habitats (93 cisterns and 49 ditches) were sampled. In second and third floors, 40 potential habitats were sampled, of which included 31 cisterns and 5 ditches. The most abundant habitats with immature mosquitoes were cisterns ( $n=83$ ), followed by ditches ( $n=29$ ), shallow waters ( $n=3$ ), used tires ( $n=1$ ) and others ( $n=2$ ). There was no significant difference between the proportions of habitats with immature mosquitoes in first story and entrance and/or exit tunnel of UPLs (60%), compared with second and third story (50%) ( $\chi^2=1.26$ ,  $df=1$ ,  $P>0.05$ ). Positive rates of habitats in cisterns, ditches and shallow waters were 67%, 54% and 25%, respectively. In UPLs for BPI, only 46% of the 67 habits were found with immature mosquitoes. While 64% of the 137 habitats in UPLs for PMRA had immature mosquitoes. The proportion of mosquito positive habitats of the latter was significantly higher than in UPLs for BPI ( $\chi^2=5.48$ ,  $df=1$ ,  $P<0.05$ ) (Figure 1).

A high positive rate of immature mosquito found from these sites may pose the concern and risk of dengue fever in the populous areas in Wuhan. The concern for potential viral outbreak is due to the fact that the most abundant habitat types in UPLs were the cisterns and the ditches. About half of positive cisterns and ditches produced a large number of mosquito larvae and/or pupae. All UPLs for PMRA were positive with immature mosquitoes.

In 2014, there was a dengue fever outbreak in Guangzhou, China with 46,780 cases reported (data from Chinese Center for Disease Control and Prevention, 2015). The primary dengue vector in



Guangzhou is *Ae. albopictus*. More than 60% *Aedes albopictus* were collected from the UPL sites in Wuhan, Central China. With the accelerated urbanization and increased populations, more and more UPLs in the densely populated metropolitan will be built. Therefore, the surveillance and control of the mosquitoes resulted by the UPLs construction will be a problem and great challenge. The study results indicate that the increase of the UPLs construction created more special breeding sites for mosquitoes, and the local mosquito control program in urban areas should enhance on the surveillance and control of mosquitoes in UPLs, especially UPLs for PMRA, to minimize the risks of mosquito-borne diseases.

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	Jiang'an District		Jiangnan District		Total	
	BPI <sup>a</sup>	PMRA <sup>b</sup>	BPI	PMRA	BPI	PMRA
No. of UPLs	10	12	4	16	14	28
<i>C. p. quinquefasciatus</i>	7	10	4	16	11	26
<i>C. p. molestus</i>	3	6	1	5	4	11
<i>Ae. albopitius</i>	4	9	1	11	5	20
Any mosquito	8	12	4	16	12	28

<sup>a</sup>BPI: Business Properties and Institutions; <sup>b</sup>PMRA: Property Management Residential Areas.

**Table 1:** Mosquito species and number of UPLs with positive immature mosquitoes in Jiang'an and Jiangnan Districts, Wuhan.