scientific reports

Check for updates

OPEN

Impact of underground storm drain systems on larval ecology of *Culex* and *Aedes* species in urban environments of Southern California

Xiaoming Wang[1,2], Guofa Zhou[1], Daibin Zhong[1], Yiji Li[1], Stacia Octaviani[1], Andrew T. Shin[1], Timothy Morgan[2], Kiet Nguyen[2], Jessica Bastear[1], Melissa Doyle[3], Robert F. Cummings[2]✉ & Guiyun Yan[1]✉

An extensive network of storm water conveyance systems in urban areas, often referred to as the "underground storm drain system" (USDS), serves as significant production habitats for mosquitoes. Knowledge of whether USDS habitats are suitable for newly introduced dengue vectors *Aedes aegypti* and *Ae. albopictus* will help guide surveillance and control efforts. To determine whether the USDS functions as a suitable larval habitat for *Culex*, *Ae. aegypti* and *Ae. albopictus* in southern California, we examined mosquito habitat utilization and larval survivorship using laboratory microcosm studies. The data showed that USDS constituted 4.1% of sampled larval habitats for *Ae. aegypti* and *Ae. albopictus*, and 22.0% for *Cx. quinquefasciatus*. Furthermore, USDS water collected in the summer completely inhibited *Aedes* larval development, but yielded a 15.0% pupation rate for *Cx. quinquefasciatus*. Food supplementation in the microcosms suggests that nutrient deficiency, toxins and other factors in the USDS water led to low success or complete failure of larval development. These results suggest that USDS habitats are currently not major productive larval habitats for *Aedes* mosquitoes in southern California. Our findings prompt inclusion of assessments of pupal productivity in USDS habitats and adult mosquito resting sites in the mosquito surveillance program.

Rapid urbanization in the past several decades have altered microclimatic conditions and natural ecology, which may subsequently affect the ecology of disease vectors and risk of mosquito-borne diseases in heavily populated landscapes[1–3]. For example, more mosquito larval habitats and higher abundance of the yellow fever mosquito *Aedes aegypti*, the most important vector of dengue, chikungunya, and Zika viruses, were found in urban areas than in suburban and rural areas in Côte d'Ivoire, Africa[4]. Similarly, not only were more larval habitats found for the Asian tiger mosquito, *Aedes albopictus*, in urban areas of southern China, *Aedes* larvae developed faster and the adult emergence rate was higher than in suburban and rural areas, partly due to higher ambient temperatures associated with heat islands in urban areas[5].

Aedes aegypti and *Ae. albopictus* are considered as the most invasive mosquitoes in the world[6,7]. In the state of California, USA, *Ae. albopictus* was introduced in 2001 and considered established in 2011, while *Ae. aegypti* was discovered in 2013[8]. In southern California, common aquatic mosquito habitats include peridomestic sources (e.g., small artificial water-holding containers, unmaintained ornamental ponds and swimming pools)[9], and an extensive network of storm water conveyance systems consisting of catch basins, manhole chambers, underground vaults, pipelines and tunnels, and is collectively referred to as the "underground storm drain system (USDS)"[10].

The USDS is designed to rapidly direct water from heavy rainstorms to large channels to slow runoff and reduce erosion, improve water quality and avoid flooding of streets, homes, and businesses. However, non-stormwater runoff into the USDS from landscape irrigation of residential and commercial establishments, as

[1]Program in Public Health, University of California, Irvine, CA 92697-4050, USA. [2]Orange County Mosquito and Vector Control District, Garden Grove, CA 92843, USA. [3]San Gabriel Valley Mosquito and Vector Control District, West Covina, CA 91790, USA. ✉email: rcummings1026@gmail.com; guiyuny@uci.edu