Observed Loss and Ineffectiveness of Mosquito Larvicides Applied to Catch Basins in the Northern Suburbs of Chicago IL, 2014

Authors: Harbison, Justin E., Layden, Jennifer E., Xamplas, Christopher, Zazra, Dave, Henry, Marlon, et al.

Source: Environmental Health Insights, 9(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/EHI.S24311

Observed Loss and Ineffectiveness of Mosquito Larvicides Applied to Catch Basins in the Northern Suburbs of Chicago IL, 2014

Justin E. Harbison[1], Jennifer E. Layden[1,2], Christopher Xamplas[3], Dave Zazra[3], Marlon Henry[3] and Marilyn O'Hara Ruiz[4]

[1]Department of Public Health Sciences. [2]Department of Medicine, Section of Infectious Diseases, Loyola University Chicago, Maywood, IL, USA. [3]North Shore Mosquito Abatement District, Northfield, IL, USA. [4]Department of Pathobiology, University of Illinois at Urbana-Champaign, Urbana, IL, USA.

ABSTRACT: In the northeastern part of the greater Chicago metropolitan area, the North Shore Mosquito Abatement District (NSMAD) treats approximately 50,000 catch basins each season with larvicide tablets as part of its effort to reduce local populations of the West Nile virus (WNV) vector *Culex pipiens*. During the 2014 season, an NSMAD technician monitored a subset of 60–195 basins weekly for 18 weeks among the communities of the District for the presence of mosquitoes. Monitoring found no clear evidence in the reduction of mosquitoes with the use of larvicides, and visual inspections of 211 larvicide-treated basins found that the majority (162, 76.8%) were missing tablets 1–17 weeks after applications. This loss of treatment may be due to the rapid dissolution or flushing of larvicides and would help explain why the larvicide appeared to be ineffective.

KEYWORDS: larvicide, catch basin, mosquitoes, West Nile virus

CITATION: Harbison et al. Observed Loss and Ineffectiveness of Mosquito Larvicides Applied to Catch Basins in the Northern Suburbs of Chicago IL, 2014. *Environmental Health Insights* 2015:9 1–5 doi: 10.4137/EHI.S24311.

RECEIVED: January 23, 2015. **RESUBMITTED:** March 16, 2015. **ACCEPTED FOR PUBLICATION:** March 18, 2015.

ACADEMIC EDITOR: Timothy Kelley, Editor in Chief

TYPE: Short Report

FUNDING: Authors disclose no funding sources.

COMPETING INTERESTS: Authors disclose no potential conflicts of interest.

CORRESPONDENCE: jharbison@luc.edu

Paper subject to independent expert blind peer review by minimum of two reviewers. All editorial decisions made by independent academic editor. Upon submission manuscript was subject to anti-plagiarism scanning. Prior to publication all authors have given signed confirmation of agreement to article publication and compliance with all applicable ethical and legal requirements, including the accuracy of author and contributor information, disclosure of competing interests and funding sources, compliance with ethical requirements relating to human and animal study participants, and compliance with any copyright requirements of third parties. This journal is a member of the Committee on Publication Ethics (COPE).

Published by Libertas Academica. Learn more about this journal.

Introduction

As part of efforts to decrease local vector populations of West Nile virus (WNV) and other mosquito-borne diseases, stormwater catch basins are often targeted for routine larvicide applications in urban areas around the world.[1–16] The North Shore Mosquito Abatement District (NSMAD) treats approximately 50,000 catch basins each season in the District's 207 sq km (80 sq mi) located in the northeastern greater Chicago IL metropolitan area. Treatment is with extended-release, 180-day larvicides, and the specific objective is to reduce local populations of the local WNV vectors *Culex pipiens* and *Cx. restuans*. NSMAD technicians begin treatment each year in May by applying a single dose of an extended-release larvicide to the catch basins. Once all basins have been treated, typically taking 10–12 weeks, an additional round of larvicide application begins in basins treated earliest in the first round as supplies and availability of seasonal staff permit. For the 2014 season, Natular™ XRT extend-release tablets (XRT: Clarke Mosquito Control Products, Inc.) were applied to basins beginning in the last week of May and continued until the second week of August. This product was chosen based on smaller scale trials performed in 2011,[17] 2012,[18] and 2013[19] by NSMAD, which suggested a range of effective control from 8 to at least 14 consecutive weeks. Basins in the southernmost 13 sq km (5 sq mi) of the district that had received the first applications in May were treated with an additional Natular™ T30 30-day tablet[20] (T30: Clarke Mosquito Control Products, Inc.) 1–2 weeks after the last XRT application (Fig. 1). The use of these two pesticides' active ingredient, spinosad, for mosquito control, including the effect on nontarget species, has been described at length elsewhere.[21–27] The additional T30 applications were ended by September when seasonal technicians were no longer available.

Methods

As part of regular catch basin monitoring performed by NSMAD, 5–45 catch basins were inspected for the presence of mosquito larvae and pupae weekly from selected basins in 12 of the 13 communities within the NSMAD operational area during 18 weeks in June to September. The 13th, a small community with a total area of only 1.2 km sq (0.45 square mi) and only 60 catch basins, was not included in inspections. Monitoring was performed by removing the circular grate of each structure with a manhole hook and taking two dip samples using a standard 350-mL dipper. The average number of mosquitoes per two dips in treated basins and those basins that had yet to be treated ("untreated") was then used

Figure 1. The two catch basin larvicides utilized by the North Shore Mosquito Abatement District in 2014: an extended-release, 180-day Natular™ XRT tablet (right) applied to all basins and an additional 30-day Natular™ T30 tablet (left) applied to XRT-treated basins in the southernmost portion of the District.

to inform NSMAD staff on larvicide effectiveness. In those cases where catch basin sump water was clear enough to see the entire bottom of the structure, the presence of XRT and/or T30 tablets was noted. When possible, a search of the bottom was made using the dipper to ensure that larvicide tablets were not hidden by sediment. Two-sample *t*-tests were used to compare average dip samples between treatments (untreated vs XRT and XRT vs XRT + T30) each week. Precipitation data were downloaded from a nearby weather station of the National Oceanic and Atmospheric Administration (NOAA) National Weather Service Forecast Office located at the Chicago O'Hare Airport (http://www.nws.noaa.gov/climate/index.php?wfo=lot). These data were used to compare the amount of rainfall in the 2014 season with rainfall in earlier years.

Results

Of the 1,521 total basins monitored, most (1,095) did not hold mosquitoes at the time they were inspected. The structures that were found to harbor larvae and/or pupae at the time of inspection had from 1 to approximately 200 mosquitoes in a dip. During the 9 weeks in which untreated and XRT-treated basins were both monitored (weeks 24–32), average dip samples were observed to be significantly different between these two treatment types in only 2 weeks. In week 30, treated basins had fewer mosquitoes than untreated basins. In week 32, treated basins had more mosquitoes than untreated basins (Table 1, Fig. 2). During the final 6 weeks of the study, when comparisons between XRT-treated and XRT + T30-treated basins could be made, no significant difference in mosquito numbers was observed between these types (Table 1, Fig.2). Two-hundred and eleven treated basins had visible bottoms,

Table 1. Comparison of average mosquitoes per dip taken weekly from 1,521 untreated, Natular™ XRT- treated, and XRT + Natular™ T30 -treated catch basins in the greater Chicago metropolitan area in 2014.

WEEK MUMBER	UNTREATED AVERAGE MOSQUITOES PER DIP	NATULAR™ XRT AVERAGE MOSQUITOES PER DIP	NATULAR™ XRT + T30 AVERAGE MOSQUITOES PER DIP	*T*-STATISTIC, *P*-VALUE
23	3.14, $N = 60$	Nil	Nil	*NA*
24	2.49, $N = 63$	0.0, $N = 10$	Nil	1.13, 0.26
25	9.8, $N = 55$	0.5, $N = 15$	Nil	1.33, 0.19
26	0.59, $N = 48$	0.0, $N = 21$	Nil	1.32, 0.19
27	1.97, $N = 49$	0.0, $N = 26$	Nil	1.91, 0.06
28	6.06, N = 34	4.0, N = 35	Nil	0.59, 0.55
29	0.72, $N = 30$	0.54, $N = 46$	Nil	0.24, 0.81
30*	7.39, $N = 33$	3.09, $N = 162$	Nil	2.47, 0.01
31	10.14, $N = 21$	7.28, $N = 43$	Nil	0.73, 0.47
32*	0.61, $N = 79$	2.72, $N = 62$	Nil	–2.39, 0.02
33	Nil	1.16, $N = 78$	Nil	*NA*
34	Nil	2.28, $N = 61$	Nil	*NA*
35	Nil	0.38, $N = 61$	0.0, $N = 8$	0.57, 0.56
36	Nil	0.61, N = 80	0.5, $N = 5$	0.09, 0.93
37	Nil	1.99, N = 66	0.19, $N = 8$	0.72, 0.47
38	Nil	1.33, N = 50	0.0, $N = 12$	0.99, 0.32
39	Nil	1.96, N = 57	0.0, $N = 26$	0.72, 0.47
40	Nil	1.96, N = 101	1.58, $N = 31$	0.38, 0.71

Notes: *Indicates those weeks in which a significant difference ($P < 0.05$) was noted between basins. Fifteen of the 1,521 basins were inspected twice. When no basins under a specific treatment were available to be sampled, *Nil* is listed.

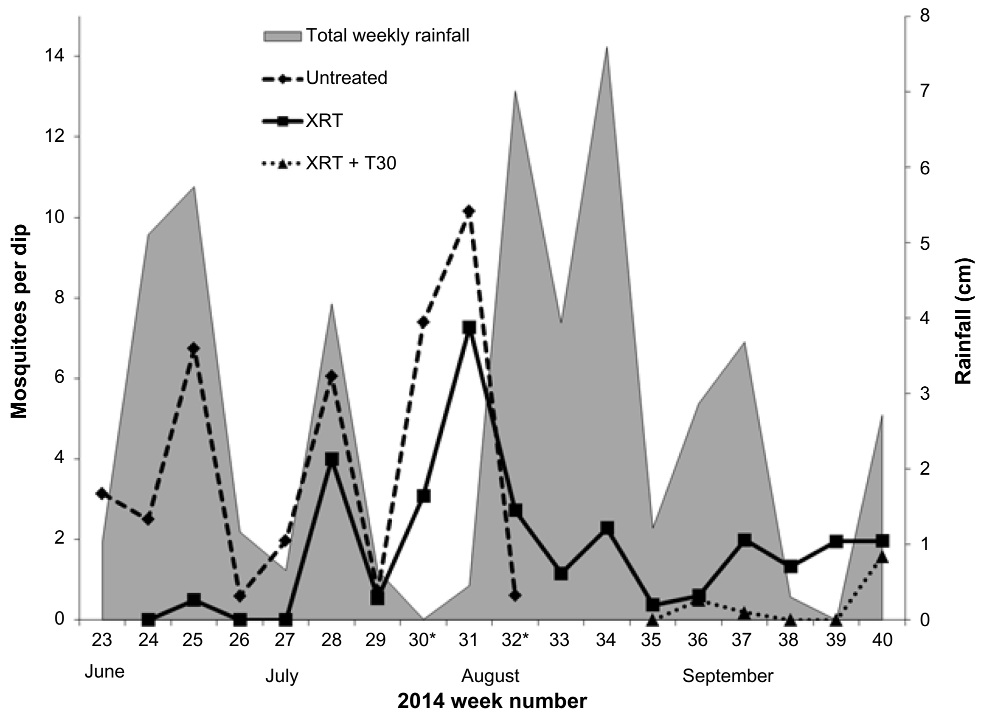

Figure 2. Average mosquitoes per dip taken weekly from untreated, Natular™ XRT- treated, and XRT + Natular™ T30-treated catch basins in the greater Chicago metropolitan area in 2014 with total weekly rainfall. *Indicates those weeks in which a significant difference ($P < 0.05$) was noted between untreated and XRT-treated basins.

of which 162 (76.8%) appeared to be missing tablets including 10 XRT + T30-treated basins that were observed with either an XRT or a T30 tablet only (9 of these missing an XRT tablet and 1 missing a T30 tablet) and 16 XRT + T30-treated basins missing both tablets. Tablets were observed missing in basins in all 12 communities from 1 to 17 weeks after applications. The total rainfall from June to September 2014 was the highest of the past five seasons (Table 2).

Discussion

Clearly, the results suggest that the effectiveness of both larvicides was less than ideal during the 2014 season. The XRT-treated basins harbored similar numbers of mosquitoes as those without larvicides, and no difference was observed between XRT + T30-treated basins when compared to those without the additional T30 application. Factors that can potentially contribute to a decreased period of efficacy are stated in these larvicides' product labels and include high rainfall or strong water flows that can flush larvicides out of structures and/or increase their rate of dissolution. Given the large number of treated basins that were observed without tablets, flushing and rapid dissolution likely occurred widely, and some direct evidence of both was observed (Figs. 3 and 4). That a large percentage of observable basins were missing treatments is clearly the most significant finding from the 2014 monitoring. The results of comparisons among untreated, XRT-treated, and XRT + T30-treated basins should be interpreted with caution, as basins associated with these treatments were spread out among the 207 sq km operational area and were likely influenced differentially by a number of site-specific factors (eg, amount of runoff and debris).

Unfortunately, by nature of their design and function to capture runoff, the influx of potentially disruptive runoff water flows is common, if not expected, in catch basins. As the XRT tablets are similar in size and weight to other commonly used extended-release larvicides (ie, Zoecon Altosid® XR Extended Residual Briquets (Wellmark International) and FourStar™ Briquets (FourStar Microbial Products LLC), a comparable degree of loss could be expected with other products. In general, the number of mosquitoes observed in NSMAD basins in 2014 appeared smaller than in some previous years,[17–19] and it is possible that runoff from this season's higher rates of rainfall could have flushed both larvicides and mosquitoes out of structures.[2,3,28–30] Currently, there are no plans by the

Table 2. Total rainfall in cm (in) from June to September 2010 to 2014. The 30 year average for this time period is 38.76 cm.

YEAR	TOTAL RAINFALL (CM)
2010	49.76
2011	48.5
2012	21.3
2013	32.8
2014	50.7

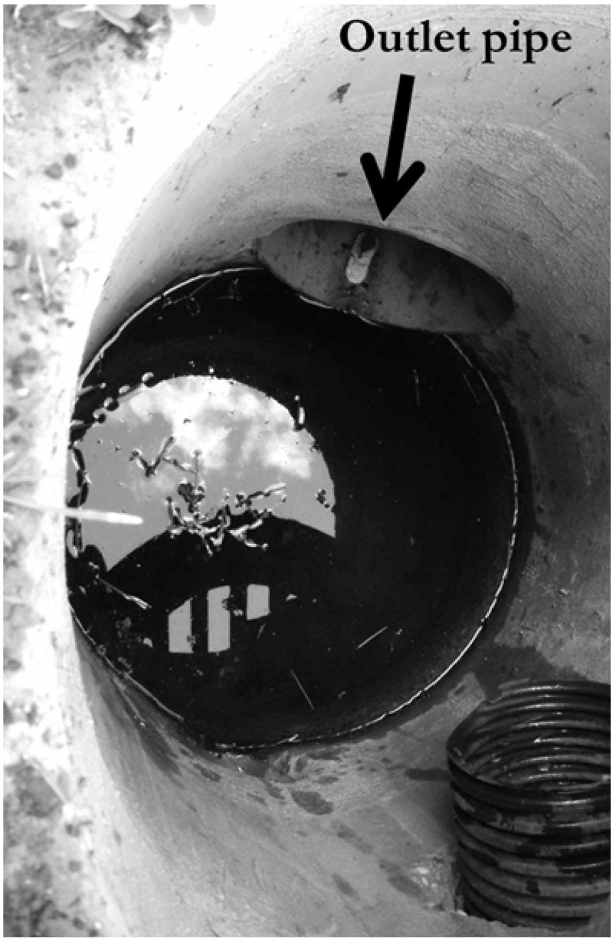

Figure 3. Evidence of catch basin larvicide flushing. A Natular™ XRT tablet is observed sitting within a catch basin's outlet pipe after initially being placed within the basin's sump water below.

NSMAD to monitor the dispersal of lost pesticide active ingredient from the catch basins.

Although the potential for flushing and/or rapid dissolution of catch basin pesticides is noted on the pesticide labels, the degree to which this occurs is not well documented and likely varies widely by locality, structure, and type of pesticide formulation (granular, tablets, vapor, etc). Certainly, that flushing and rapid dissolution occur is not surprising, particularly given that rainfall during monitoring was so high, but the degree to which these phenomena were indirectly observed was unexpected. As it is logistically difficult for mosquito control programs to monitor both mosquitoes and associated treatments within even a small percentage of their catch basins (ie, removal of heavy manhole grates, proximity to vehicular traffic), there is paucity of studies on this subject. Depending on the size and resources of local programs, monitoring of mosquitoes within a certain portion of catch basin may not even occur at all. Finally, it is not routine for mosquito control personnel to publish studies in more formal and academic publications, and thus such work cannot be found by common research search engines such as PubMed and Google Scholar.

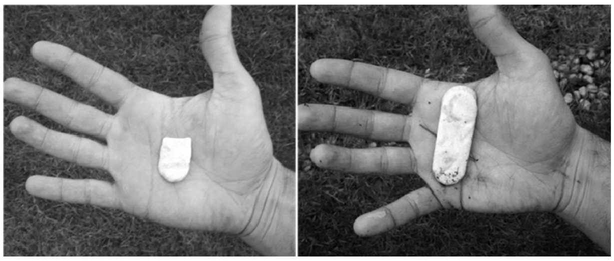

Figure 4. Evidence of rapid dissolution of a Natular™ XRT tablet. Photos show two tablets, each placed 9 weeks earlier within the sump water of a catch basin located across a residential street from each other. Although applied at the same time, the tablet on the left appears to have dissolved more rapidly than the one on the right.

Most monitored basins in this study did not hold mosquitoes at the time of inspections; however, long term monitoring by the NSMAD has found that local mosquito populations fluctuate greatly and during some seasons a much greater percentage of these widespread and abundant structures will harbor mosquitoes at various points in times. Due to their great prevalence and propensity to harbor *Cx. pipiens* in urban areas, the use of catch basin larvicides is an important consideration for mosquito control efforts, but ensuring that these pesticides remain in structures for their designed duration is a significant challenge. As an alternative to pesticide applications, the use of manhole inserts to deter mosquitoes from entering basins has seen some success in small-scale experimental trials,[31–33] but this have yet to be implemented on a wider scale. Such an intervention would likely require collaborations with local stormwater agencies and a prohibitively large financial investment in stormwater infrastructure.

Author Contributions

Conceived, designed, and performed the experiments: JEH, MH. Analyzed the data: JEH. Wrote the first draft of the manuscript: JEH, DZ, CX, JEL, MH, MOR. All authors reviewed and approved of the final manuscript.

REFERENCES

1. Lauret TH. Problems in the treatment of residential catch basins. *Calif Mosq Control Assoc*. 1953;22:73–4.
2. Munstermann LE, Craig GB Jr. Culex mosquito populations in the catch basins of northern St. Joseph County, Indiana. *Proc Indiana Acad Sci*. 1977;86:246–52.
3. Knepper RG, Leclair AD, Strickler JD, Walker ED. Evaluation of methoprene (Altosid XR) sustained-release briquets for control of Culex mosquitoes in urban catch basins. *J Am Mosq Control Assoc*. 1992;8:228–30.
4. McCarry MJ. Efficacy and persistence of Altosid pellets against Culex species in catch basins in Michigan. *J Am Mosq Control Assoc*. 1996;12:144–6.
5. Raval-Nelson P, Soin K, Tolerud S. Analysis of *Bacillus sphaericus* in controlling mosquito populations in urban catch basins. *J Environ Health*. 2005;67:28–31.
6. Rey JR, O'Meara GF, O'Connell SM, Cutwa-Francis MM. Factors affecting mosquito production from stormwater drains and catch basins in two Florida cities. *J Vector Ecol*. 2006;31(2):334–43.
7. Kobayashi M, Kasai S, Sawabe K, Tsuda Y. Distribution and ecology of potential vector mosquitoes of West Nile Fever in Japan. *Global Environ Res*. 2008;12:27–33.
8. Tedesco C, Ruiz M, McLafferty S. Mosquito politics: local vector control policies and the spread of West Nile Virus in the Chicago region. *Health Place*. 2010;16:1188–95.
9. Anderson JF, Ferrandino FJ, Dingman DW, Main AJ, Andreadis TG, Becnel JJ. Control of mosquitoes in catch basins in Connecticut with *Bacillus thuringiensis* israelensis, and spinosad. *J Am Mosq Control Assoc*. 2011;27:45–55.

10. Poletti P, Messeri G, Ajelli M, Vallorani R, Rizzo C, Merler S. Transmission potential of Chikungunya virus and control measures: the case of Italy. *PLoS One*. 2011;6:e18860.
11. Guidi V, Lüthy P, Tonolla M. Comparison between diflubenzuron and a *Bacillus thuringiensis* israelensis- and *Lysinibacillus sphaericus*-based formulation for the control of mosquito larvae in urban catch basins in Switzerland. *J Am Mosq Control Assoc*. 2013;29:138–45.
12. Jackson MJ, Gow JL, Evelyn MJ, et al. Modelling factors that affect the presence of larval mosquitoes (Diptera: Culicidae) in stormwater drainage systems to improve the efficacy of control programmes. *Can Entomol*. 2013;145:674–85.
13. Manrique-Saide P, Arisqueta-Chablé C, Geded-Moreno E, et al. An assessment of the importance of subsurface catch basins for *Aedes aegypti* adult production during the dry season in a neighborhood of Merida, Mexico. *J Am Mosq Control Assoc*. 2013;29:164–7.
14. Montarsi F, Martini S, Dal Pont M, et al. Distribution and habitat characterization of the recently introduced invasive mosquito *Aedes koreicus* [Hulecoeteomyia koreica], a new potential vector and pest in north-eastern Italy. *Parasit Vectors*. 2013;6:292.
15. Arana-Guardia R, Baak-Baak CM, Loroño-Pino MA, et al. Stormwater drains and catch basins as sources for production of *Aedes aegypti* and *Culex quinquefasciatus*. *Acta Trop*. 2014;134:33–42.
16. Ocampo CB, Mina NJ, Carabalí M, Alexander N, Osorio L. Reduction in dengue cases observed during mass control of Aedes (Stegomyia) in street catch basins in an endemic urban area in Colombia. *Acta Trop*. 2014;132C:15–22.
17. Harbison JE, Henry M, Xamplas C, Berry R. Experimental use of Natular™ XRT tablets in a North Shore suburb of Chicago, IL. *J Am Mosq Control Assoc*. 2013;29:237–42.
18. Harbison JE, Henry M, Xamplas C, Berry R, Bhattacharya D, Dugas LR. A comparison of FourStar™ briquets and Natular™ XRT tablets in a North Shore suburb of Chicago, IL. *J Am Mosq Control Assoc*. 2014;30:68–70.
19. Harbison JE, Henry M, Xamplas C, Dugas L. Evaluation of *Culex pipiens* populations in a residential area with a high density of catch basins in a suburb of Chicago, Illinois. *J Am Mosq Control Assoc*. 2014;30:228–30.
20. Su T, Cheng ML, Thieme J. Laboratory and field evaluation of spinosad formulation Natular T30 against immature Culex mosquitoes (Diptera: Culicidae). *J Med Entomol*. 2014;51:837–44.
21. Su T, Cheng ML. Cross resistances in spinosad-resistant *Culex quinquefasciatus* (Diptera: Culicidae). *J Med Entomol*. 2014;51:428–35.
22. Su T, Cheng ML. Laboratory selection of resistance to spinosad in *Culex quinquefasciatus* (Diptera: Culicidae). *J Med Entomol*. 2014;51:421–7.
23. Marina CF, Bond JG, Muñoz J, Valle J, Novelo-Gutiérrez R, Williams T. Efficacy and non-target impact of spinosad, Bti and temephos larvicides for control of Anopheles spp. in an endemic malaria region of southern Mexico. *Parasit Vectors*. 2014;7:55.
24. Jones OM, Ottea J. The effects of spinosad on *Culex quinquefasciatus* and three nontarget insect species. *J Am Mosq Control Assoc*. 2013;29:346–51.
25. Lawler SP, Dritz DA. Efficacy of spinosad in control of larval Culex tarsalis and chironomid midges, and its nontarget effects. *J Am Mosq Control Assoc*. 2013;29:352–7.
26. Su T, Cheng ML. Resistance development in *Culex quinquefasciatus* to spinosad: a preliminary report. *J Am Mosq Control Assoc*. 2012;28:263–7.
27. Marina CF, Bond JG, Muñoz J, Valle J, Chirino N, Williams T. Spinosad: a biorational mosquito larvicide for use in car tires in southern Mexico. *Parasit Vectors*. 2012;5:95.
28. Maddock DR, Elmore J, Schoof HF. Preliminary tests with DDVP vapour for the control of *Culex pipiens quinquefasciatus* in catch basins. *Mosq News*. 1963;23:60–74.
29. Stockwell PJ, Wessell N, Reed DR, et al. A field evaluation of four larval mosquito control methods in urban catch basins. *J Am Mosq Control Assoc*. 2006;22:666–71.
30. Koenraadt CJ, Harrington LC. Flushing effect of rain on container-inhabiting mosquitoes *Aedes aegypti* and *Culex pipiens* (Diptera: Culicidae). *J Med Entomol*. 2008;45:28–35.
31. Duckworth TN, Musa CP. Study of a mosquito prevention device for catch basins in Warren County, New Jersey. *Wing Beats*. 2009;20:35–41.
32. Harbison JE, Metzger ME, Allen IIV, Hu R. Evaluation of manhole inserts as structural barriers to mosquito entry into belowground stormwater systems using a simulated treatment device. *J Am Mosq Control Assoc*. 2009;25:356–60.
33. Harbison JE, Metzger ME, Hu R. Association between *Culex quinquefasciatus* (Diptera: Culicidae) oviposition and structural features of belowground stormwater treatment devices. *J Med Entomol*. 2010;47:67–73.