Journal of Medical Entomology, 55(4), 2018, 955–963
doi: 10.1093/jme/tjy011
Advance Access Publication Date: 19 February 2018
Research Article

OXFORD

Sampling, Distribution, Dispersal

Socioeconomic and Human Behavioral Factors Associated With *Aedes aegypti* (Diptera: Culicidae) Immature Habitat in Tucson, AZ

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Subject Editor: Lars Eisen

Received 19 October 2017; Editorial decision 8 January 2018

Abstract

Aedes aegypti (L.; Diptera: Culicidae) has been established in the southwestern United States for several decades, but relationships between humans and mosquitoes in this arid region are not well-characterized. In August 2012, the outdoor premises of 355 houses within 20 neighborhoods in Tucson, Arizona were surveyed for containers that could provide larval habitat for *Ae. aegypti* mosquitoes. At the same time, a knowledge, attitudes and practices (KAP) questionnaire was administered to a resident of each house surveyed for immature mosquitoes. The KAP questionnaire assessed respondents' knowledge and concerns about vector-borne illnesses as well as practices they used to avoid mosquitoes. Of the houses surveyed, 91% had at least one container present, and 64% had at least one container with standing water. On average, each house had 2.2 containers with water at the time of the survey. The overall House Index (proportion of premises surveyed with at least one container with *Ae. aegypti* immatures present) was 13%. Based on questionnaire responses, there was a significant positive association between the number of residents in the home and the odds of finding *Ae. aegypti* positive containers on the premises, while household income showed a significant negative association. The reported frequency of checking for standing water was also significantly associated with the odds of finding immatures, although the nature of this association was ambiguous. Flower pots were the principal type of container with *Ae. aegypti* larvae. These findings show that larval habitat is widely available even in an arid environment and city with good housing and sanitation infrastructure.

Key words: *Aedes aegypti*, southwestern United States, arbovirus, larval habitat

Dengue, chikungunya, and Zika are important arboviral diseases that are expanding their geographic range (Saxena et al. 2006, Roth et al. 2014, Musso et al. 2015). The Centers for Disease Control and Prevention (CDC 2015) estimates nearly 2.5 billion people worldwide live in areas with risk of dengue infection. Over 60 countries in Asia, Africa, Europe, and the Americas have local transmission of CHIKV (WHO 2016), and 85 countries have reported ZIKV transmission (WHO 2017). *Aedes aegypti* (L.; Diptera: Culicidae) is one of the main vectors of these arboviruses worldwide. Originally native to Africa, *Ae. aegypti* is now established in tropical and subtropical areas around the world (Tabachnik and Powell 1979). Highly invasive, this species' close association with humans has facilitated the expansion of its range (Kraemer et al. 2015).

Ae. aegypti readily enters houses, feeds preferentially on human blood, and uses human-made containers for larval development. It lays drought-resistant eggs on the sides of water-filled containers (Christophers 1960). While this species uses a range of water-holding containers for oviposition, the types of containers available and their relative importance to *Ae. aegypti* populations vary between regions. For example, studies in Bangladesh and Malaysia found tires and small plastic receptacles to be the predominant types of container for *Ae. aegypti* development (Ferdousi et al. 2015, Dom et al. 2016), while in Brazil, Pinheiro and Tadei (2002) found flower pots and other earthenware receptacles to be the most productive larval habitats. Lack of reliable piped water can contribute to water storage and, consequently, mosquito larval habitat (Kuno 1997).

Lack of regular trash removal can also lead to the accumulation of discarded containers that collect rainwater and support mosquitoes (Barrera et al. 1995).

While *Ae. aegypti* densities are higher in humid areas, human modifications of the environment such as irrigation and water storage have allowed the mosquito to establish and maintain populations even in arid regions such as the Sonoran desert of the southwestern United States. It is not known when *Ae. aegypti* first arrived in the Sonoran region, but its presence in Tucson, Arizona was documented in the 1930s (Bequaert 1946, Murphy 1953). The species seemed to have disappeared from Arizona by the 1950s (Hayes and Tinker 1958, McDonald et al. 1973) and reappeared in 1994 (Fink et al. 1998). The current southern Arizona *Ae. aegypti* population structure exhibits a close genetic relationship to populations in the Pacific coast of Mexico (Merrill et al. 2005). Studies of *Ae. aegypti* distribution in Tucson using oviposition traps found positive associations between mosquito presence and highly vegetated areas (Hayden et al. 2010) and older houses (Walker et al. 2011). On-going research in southern Arizona and the neighboring state of Sonora in Mexico have found population densities of *Ae. aegypti* to be similar or higher in Tucson than in nearby Mexican cities (unpublished data). Although several introductions of another DENV vector (*Aedes albopictus* (Skuse)) have occurred, this mosquito is not currently known to be established in Arizona (ADHS 2017).

Between 2006 and 2016, an average of 17 cases of dengue associated with travel were reported annually in Arizona, but no locally acquired cases have been reported (ADHS 2016). In 2014, an outbreak of dengue occurred near the Arizona/Sonora border in the Mexican city of San Luis Río Colorado, and 70 travel-related dengue cases were confirmed in nearby Yuma, AZ (Jones et al. 2016). As seen in Texas (Reiter et al. 2003), better housing and sanitation infrastructure in the continental United States may contribute to the differences in DENV transmission in the Arizona/Sonora region. Regular trash collection, use of lawn services, reliable indoor plumbing and better constructed housing could reduce the availability of larval habitat and impede human-vector contact. Availability of *Ae. aegypti* larval habitat in areas such as Tucson, AZ is not well-known, and few container surveys for *Ae. aegypti* have been conducted recently in the southwestern United States.

Because of the close association between *Ae. aegypti* and humans, the availability of mosquito immature habitat may be influenced by human understanding of this vector. Knowledge, attitudes and practices (KAP) surveys are established assessment tools and have been used to evaluate dengue education programs and investigate connects between dengue knowledge and source reduction in countries with significant DENV transmission (Lloyd et al. 1992, Degallier et al. 2000, Winch et al. 2002, Sanchez et al. 2005, Koenraadt et al. 2006). Combining results from KAP surveys with *Ae. aegypti* immature habitat assessment has the potential to identify effective health education messages and target interventions.

This study builds upon the KAP survey by Haenchen et al. (2016) that found stronger associations between knowledge and mosquito avoidance practices among residents of Key West, FL, a city with a recent history of local DENV transmission, than among Tucson residents. In the study presented here, we examined associations between human factors derived from the KAP survey with the number of containers providing either potential or actual *Ae. aegypti* immature habitat on residential properties within Tucson neighborhoods. The study also assessed the relative mosquito productivity of different types of water containers to determine which are critical to supporting *Ae. aegypti* populations in this region.

Materials and Methods

Site Description

Tucson is located in southern Arizona approximately 120 km north of the border with Mexico. At an elevation of 807 m above sea level, Tucson has a subtropical steppe climate with average annual rainfall of 294 mm, average January minimum temperature of 4.3°C, and an average August maximum temperature of 36.3°C (NWS 2017). The second largest city in the state, Tucson's population in 2010 was 520,561 (U.S. Census Bureau 2015). The Pima county health department conducts mosquito surveillance using CO_2 trapping of adult mosquitoes and testing of mosquito pools for arboviruses. Control efforts primarily target *Culex* mosquitoes and involve applications of bacterial larvicide to large water bodies (Pima County 2017).

Study Design and Sample Selection

In this study, the outdoor premises of Tucson homes were inspected to identify larval habitat for *Ae. aegypti* mosquitoes. At the same time, residents were interviewed to determine KAP regarding mosquitoes and mosquito-borne diseases (Haenchen et al. 2016). Household questionnaires and larval surveys were conducted in August 2012 by field teams consisting of two trained personnel. The study coincided with peak mosquito activity directly following monsoon rains (Hayden et al. 2010), and the sampling period was restricted to 1 mo to reduce seasonal variation in responses. A total of 20 neighborhoods were chosen using ArcGIS (Redlands, CA) by generating 20 points across Tucson that were at least 1 km apart. Within each neighborhood, 20 residential parcels were randomly selected for a total of 400 premises (Fig. 1).

Households were recruited for participation in the study using standardized procedures described in Haenchen et al. (2016). Only 25% of participating respondents were from the 400 original randomly selected homes, while the rest were from nearby homes recruited for participation due to refusals or the inability to locate residents of the original homes. Due to time constraints and some households choosing to participate only in the household questionnaire or the larval survey, a total of 355 homes were sampled both by the KAP questionnaire and the outdoor larval survey.

Ethics Statement

A consent form was read to participating residents that indicated they were under no obligation to participate and could stop at any time. Consent to participate was obtained verbally. Data were collected only from adults in households who agreed to participate. The study protocol was determined exempt by the University of Arizona Human Subjects Research Committee.

Larval Habitat Surveillance

At each household surveyed, the outdoor premises were inspected for the presence of potential water-holding containers. At some households, the respondents chose to limit premise inspection to the front yard only, which was noted as a factor in subsequent analyses. Any vessel that could hold water and provide a suitable habitat for mosquito immatures was recorded. Containers were identified as either small (<200 liters) or large (>200 liters), and categorized by type (i.e., trash, tire, plastic container, flower pot, toy, cement

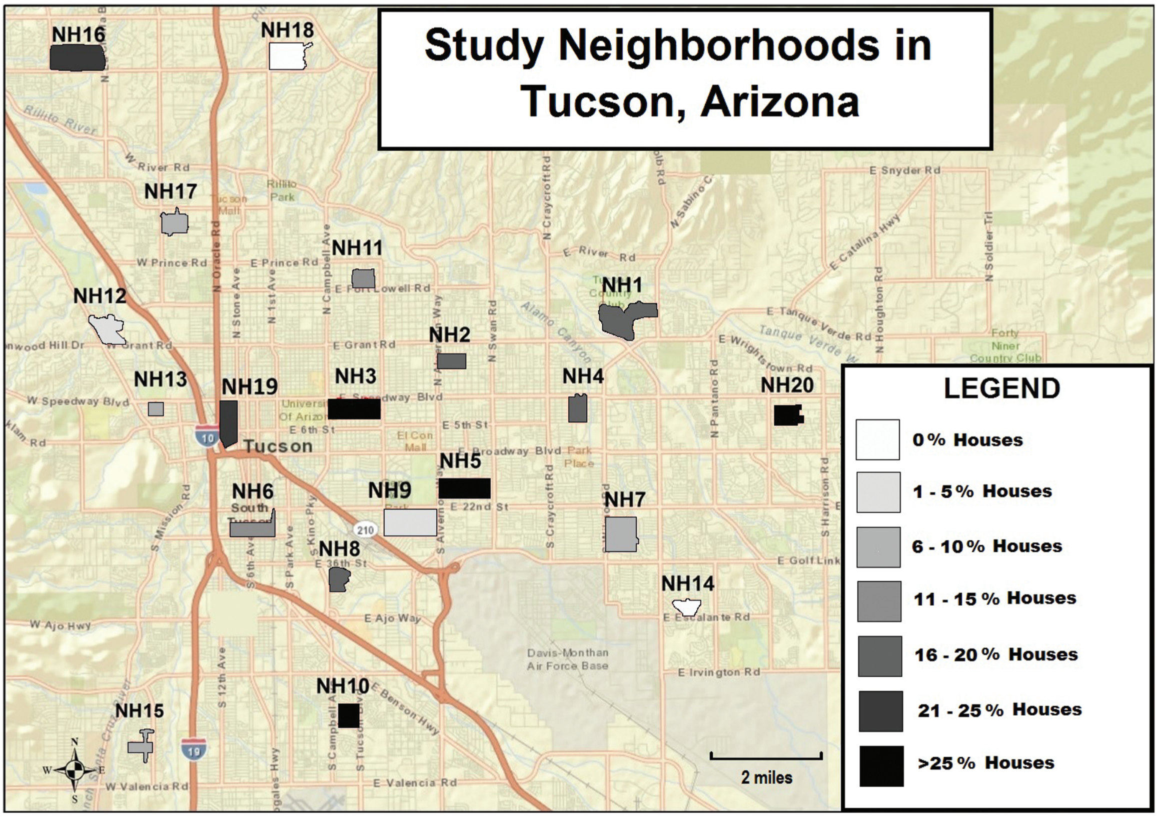

Fig. 1. Map of study neighborhoods showing House Index - percent houses per neighborhood with at least one container with *Ae. aegypti* larvae or pupae.

trough, tarp, other small container, large container). Each container was examined for the presence of water and mosquito immatures. If mosquito larvae or pupae were found, a sample was collected and transported to the University of Arizona for species identification. When mosquito immatures were found at a residence, the samples were shown to the resident, and methods of preventing future infestations were discussed.

Household Mosquito-Borne Disease Prevention and Control Survey

The KAP survey included approximately 80 questions addressing topics including awareness and perceived risk of mosquito-borne diseases, knowledge of mosquito breeding, practices to avoid mosquito bites and reduce mosquito populations, perceptions about mosquito control methods, residential history and demographic information (Haenchen et al. 2016). From these questions, fourteen factors were analyzed as possible explanatory variables associated with *Ae. aegypti* larval habitat abundance (Table 1).

Data Analysis

All statistical analyses were run using JMP (JMP, version 12.1). Principal containers were assessed from the simple linear regression of the proportion of each container types that held *Ae. aegypti* immatures (larvae or pupae) and the proportion of the different types of containers with water in them (Moore et al. 1978). We used studentized residuals from this analysis to identify container types that may have contained significantly more *Ae. aegypti* immatures than expected based on the relative container abundance. Ninety-five percent of studentized residuals (i.e., residuals divided by their standard deviation) are expected to fall between −2 and 2 in normally distributed populations (Ramsey and Shafer 2002). As nine container types were evaluated in this study, container types with large studentized residuals (i.e., >2) could indicate containers with a relatively high number of immatures. Simple linear regression was also used to assess associations between the total number of containers per house and the number of wet containers as well as between the number of containers with *Ae. aegypti* larvae and pupae. The container variables were log-transformed to improve assumptions of normality.

The associations between the human socio-demographic and behavioral factors (explanatory variables) (Table 1) and four response variables (total number of containers per house, total containers with water, total containers with *Ae. aegypti* larvae, and total containers with *Ae. aegypti* pupae) were evaluated using multiple regression models. Associations between human factors and the total number of containers and the total number of containers with water per house were evaluated with log-linear regression models with Poisson distribution. Because most houses had either 0 or 1 container with larvae (i.e., 96%) or pupae (i.e., 98.9%), the associations between the odds of containers with larvae or pupae and the explanatory variables (Table 1) were assessed with logistic regression for binary data. Number of explanatory variables was relatively large (Table 1). To avoid including unnecessary explanatory variables that could reduce precision of statistical models (Ramsey and Shafer 2002), we first fit a full model with all explanatory variables, which was followed by a reduced, inferential model only containing explanatory variables with P-values ≤ 0.1 in the full model. This approach is similar to using stepwise regression with backward elimination, which tends to select inferential models that have too many significant explanatory variables compared to variable selection procedures that compare all

Table 1. Human factors (housing, behavior, demographics) used in statistical analyses of the four response variables (total container counts per house, total containers with water, total containers with *Ae. aegypti* larvae and total containers with *Ae. aegypti* pupae)

Explanatory variables	Variable type	Range
Housing factors		
Housing type	Categorical	Single home or multi-family apartments
Home ownership	Categorical	Owner or renter
Neighborhood	Categorical	1 to 20
Year house was built	Continuous	1905 to 2008 (mean = 1965, SE = 1)
Percent of yard with vegetation	Categorical	<25%; 25–50%; 51–75%, >75%
Percent of yard shaded	Categorical	No shade; little shade; half shade; much shade
Human and behavioral factors		
Number of people in house	Continuous	1 to 6 persons (mean = 2.21, SE = 0.05)
Number of children under 5	Continuous	0 to 3 children (mean = 0.21, SE = 0.03)
Number of children 5 to 18	Continuous	0 to 4 children (mean = 0.50, SE = 0.05)
Household income	Categorical	<$35,000; $35,000–49,990; $50,000–74,999; $75,000–99,999; ≥$100,000
Reported frequency of removing standing water[a]	Categorical	Never; after every rainfall; once or twice a month; once a week; >once a week; daily
Use of yard service	Categorical	Yes or no
Survey factors		
Front yard only	Categorical	Yes or no
Surveyor	Categorical	14 different surveyors

[a]Respondents who did not know or declined to answer were not included in the analysis.

possible subsets of models (Ramsey and Shafer 2002). Indicator variables were used in each reduced model to contrast levels of the categorical variables to a reference level (Table 1, Supplementary Tables S1–S3).

For each of the nine types of containers investigated, the association between household income and total number of containers per house was evaluated with simple log-linear regression. For each type of container, we used indicator variables to contrast the number of containers between houses with the lowest income category and houses with higher income categories (Table 1). An overdispersion parameter was used in all log-linear regression models because the goodness-of-fit test was significant ($P < 0.001$) and use of this parameter greatly reduced the value of the Akaike's Information Criterion (AIC) (SAS Institute 2012).

Results

Larval Density Indices

Resident questionnaires and outdoor inspections were completed at 355 homes. Outdoor inspections yielded a total of 3,948 containers; 793 (20%) of those containers held water; 70 (1.8%) contained *Ae. aegypti* larvae, and 27 (0.7%) contained *Ae. aegypti* pupae. At least one container was found at 323 houses (91% of houses surveyed), and at least one container with water was found at 227 houses (64% of houses surveyed). *Ae. aegypti* immatures were found in 18 of the 20 neighborhoods surveyed. The House Index (percent of all surveyed households with at least one container with *Ae. aegypti* larvae or pupae) was 13% (46 houses out of 355). The Container Index, or the percent of water-holding containers positive for *Ae. aegypti* larvae or pupae, was 8.8%. The Breteau Index (number of *Ae. aegypti* positive containers per 100 houses) was 19.7. A significant positive association was found between total number of containers and the number of containers with water at each house (slope = 0.41, SE = 0.03, R^2 = 29.8%, $P < 0.0001$). A stronger association was observed between the number of containers with larvae and the number of containers with pupae at each house (slope = 0.46, SE = 0.02, R^2 = 58.0 %, $P < 0.0001$).

Container Types

The most abundant containers used as larval habitat were flower pots (and the associated saucers underneath them) and plastic containers (Fig. 2). The proportion of each type of container that held *Ae. aegypti* immatures (larvae or pupae) generally reflected the relative abundance of the different types of containers with water in them (slope = 1.21, SE = 0.14, R^2 = 92.0 %, $P < 0.0001$). All container types except flower pots had studentized residuals between ±1.11. The studentized residual for flower pots was 2.13, suggesting flower pots contained more *Ae. aegypti* immatures than would be expected based on their relative abundance. The principal container plot supports these findings (Fig. 3).

Ae. aegypti Habitat and Human Factors

Results from the regression analyses of *Ae. aegypti* container habitat and human factors are summarized in Tables 2 and 3. Many factors were significantly associated with the total number of containers found at each household (Table 2). Number of people in the home was positively associated with total container number (slope = 0.15, SE = 0.06), and home owners had more containers on average than renters (Supplementary Table S1a). Houses with low income had more containers than houses with higher income (Supplementary Fig. 1, Supplementary Table S1b), and use of yard service reduced the number of total containers (Supplementary Table S1c). There was little difference in number of total containers between those respondents who reported checking more frequently and those who reported checking less frequently, except those who reported checking after every rainfall and daily, who had more containers than residents that never checked (Supplementary Table S1d). Total container number also varied significantly with neighborhood, surveyor and surveillance of the front yard only (Table 2). In contrast to total container number, only three explanatory variables showed significant associations with the total number of containers with water: neighborhood, surveyor and surveillance of the front yard only (Table 2).

The odds of finding one or more containers with *Ae. aegypti* larvae at a residence were significantly associated with several human factors (Table 3 and Supplementary Tables S2). Presence of larvae was positively associated with the number of people in the home

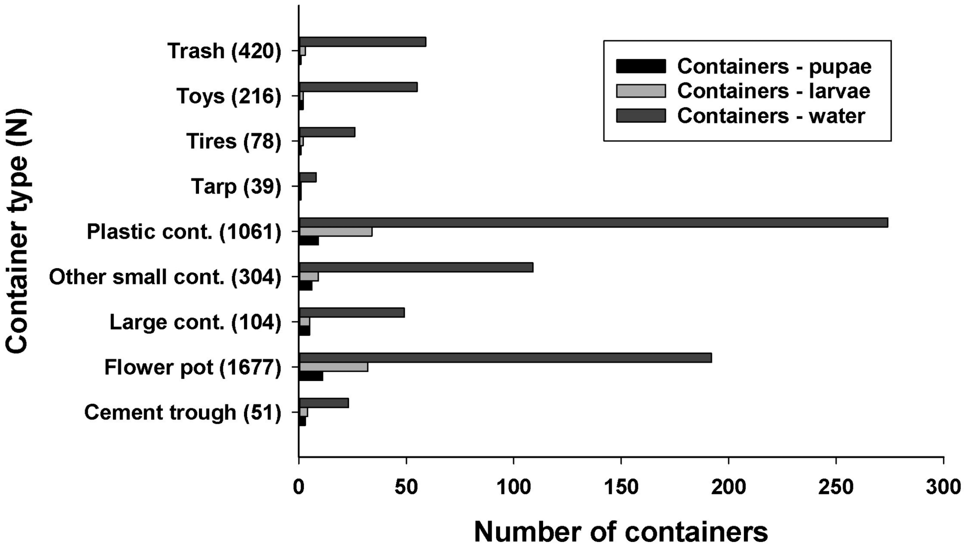

Fig. 2. Type and abundance of containers found in outdoor premises. The number (*n*) in parentheses next to each container indicates the total number of containers of that type.

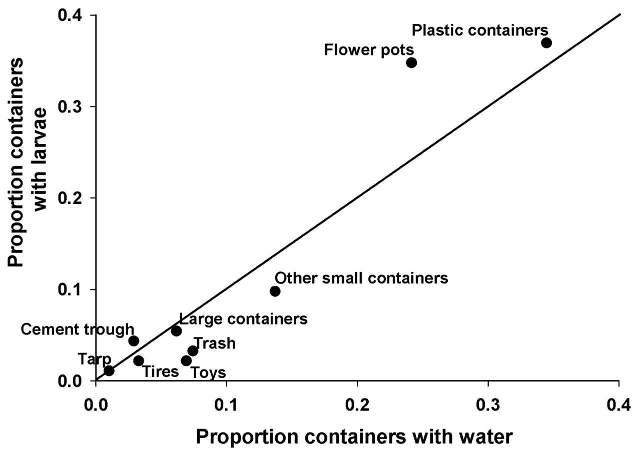

Fig. 3. Principal container plot showing the relative prevalence of *Ae. aegypti* immatures in different types of containers. Continuous line represents the expected utilization of different types of containers by *Ae. aegypti* if all types of containers were used equally. Containers above the line are those used more frequently than abundance would indicate.

(slope = 0.65, SE = 0.31). A negative trend was present between house income and the odds of finding larvae, although only middle-income houses had significantly lower odds of finding larvae than low-income houses (Supplementary Table 2a). Frequency of checking for standing water was significantly associated with the odds of finding larvae (Table 3). Compared to respondents who newer checked for standing water, the odds of finding larvae tended to decline for respondents who checked for standing water once a week or more, although the odds of finding larvae was only significantly lower in respondents that checked more than once a week (Supplementary Table S2b). The effects of surveyor and surveillance of the front yard only were also significant (Table 3).

The odds of finding *Ae. aegypti* pupae at a residence were significantly associated with home ownership, household income and surveillance limited to the front yard (Table 3 and Supplementary Table S3). The odds of finding pupae were lower for home renters than owners (Supplementary Table 3a) and generally declined as house income increased (Supplementary Table 3b). The reported frequency of checking for standing water was also significantly associated with the odds of finding pupae, as respondents who said they checked more than once per week were less likely to have pupae than respondents that did not check (Supplementary Table S3c). However, there was a notable nonsignificant trend for respondents who reported checking daily to be more likely to have pupae than respondents who checked less frequently or not all.

Household Income and Container Types

Analyses of household income level and types of containers present revealed that the odds of finding certain types of containers (trash, flower pots, and toys) was generally lower for households with higher incomes (Supplementary Table S4). By contrast, respondents in the highest income groups had significantly more tarps and large containers than the lowest income group. Associations between income and other container types were not significant (Supplementary Table S4).

Discussion

This study demonstrates the abundance and widespread distribution of *Ae. aegypti* larval habitat throughout the city of Tucson. All but two neighborhoods surveyed had at least one home with *Ae. aegypti* present. More than half of houses surveyed had potential *Ae. aegypti* larval habitat (one or more containers with standing water). While the House Index was low (13%), it is similar to that observed in Hermosillo, Sonora (9%), where *Ae. aegypti* is known to transmit several arboviruses (Ernst et al. 2016).

The most common types of containers with *Ae. aegypti* immatures were flower pots (and associated saucers) and plastic containers. The disproportionate exploitation of flower pots saucers by *Ae. aegypti* immatures indicates that these structures were particularly important to the mosquitoes. Flower pot saucers comprised 45.7% of the total containers with larvae and 40.7% of the containers with pupae. Saucers under large pots that required special efforts to lift and inspect were particularly likely to harbor mosquito immatures.

Table 2. Human factors significantly associated with number of outdoor containers

Explanatory variables	DF	Total containers on premises		Total containers with water on premises	
		χ^2	*P*-value	χ^2	*P*-value
House factors					
Home ownership	1	11.60	0.0007[a]	-	-
Neighborhood	19	58.81	<0.0001[a]	44.44	0.001[a]
Percent of yard shaded	3	-	-	5.88	0.12
Human and behavioral factors					
Number of people in house	1	6.48	0.01[a]	-	-
Household income	4	18.58	0.001[a]	-	-
Reported frequency of removing standing water	5	18.30	0.003[a]	-	-
Use of yard service	1	7.48	0.006[a]	-	-
Survey factors					
Front yard only	1	8.15	0.004[a]	7.78	0.005[a]
Surveyor	13	135.29	<0.0001[a]	38.86	0.0002[a]

Results are based on the reduced regression models only containing explanatory variables with *P*-values ≤ 0.1 in the full models.
[a]Explanatory variables with significant associations with response variables in final reduced model, *P* ≤ 0.05.

Table 3. Human factors significantly associated with *Ae. aegypti* presence

Explanatory variables	DF	Odds of finding containers with *Ae. aegypti* larvae		Odds of finding containers with *Ae. aegypti* pupae	
		χ^2	*P*-value	χ^2	*P*-value
House factors					
Home ownership	1	-	-	7.68	0.006[a]
Neighborhood	19	33.49	0.03[a]	34.47	0.02[a]
Percent yard vegetated	3	6.48	0.09	-	-
Human and behavioral factors					
Number of people in house	1	4.29	0.04[a]	-	-
Number of children under five	1	1.42	0.23	-	-
Household income	4	8.91	0.06	18.11	0.001[a]
Reported frequency of removing standing water	5	15.36	0.009[a]	12.93	0.02[a]
Survey factors					
Front yard only	1	4.38	0.04[a]	11.32	0.0008[a]
Surveyor	13	45.47	<0.0001[a]	25.04	0.02[a]

Results are based on the reduced regression models only containing explanatory variables with *P*-values ≤ 0.1 in the full models.
[a]Explanatory variables with significant associations with response variables in final reduced model, *P* ≤ 0.05.

Interestingly, Cavalcanti et al. (2016) observed a shift to exploitation of flower pots by *Ae. aegypti* populations in northeast Brazil, possibly in response to public health campaigns to reduce larval habitat in water tanks and tires. Though we found over 400 containers identified as trash, only three contained *Ae. aegypti* immatures. Scrap tires, a type of container frequently associated with *Aedes* vectors (Beier et al. 1983, Uejio et al. 2014), were uncommon (78 total) and only two contained mosquitoes. The vast majority of containers were small, as large containers (>200 liter capacity) represented only 2.6% of the total containers. Among the large containers, unmaintained pools, associated with West Nile virus vectors in California (Reisen et al. 2008), were rare (11 total) and none contained larvae.

The four container response variables measured examined different aspects of human factors that influence *Ae. aegypti* habitat and population density. The total number of containers reflected the amount and types of objects (and clutter) of the outdoor premises of residences that could possibly support mosquitoes. Containers with water were intended to measure potential larval habitat available to female mosquitoes seeking oviposition sites at the time of the study. The utility of this response variable, however, may have been reduced by fluctuating August weather conditions in Tucson. Heavy rainfalls followed by high temperatures and reduced humidity could cause rapid changes in the number of containers with water, possibly introducing high variation in sampling results. Containers with larvae reflected mosquito distribution and density, although the traditional container-based larval indices (House, Container, and Breteau) do not address actual numbers of mosquitoes produced, and therefore are limited predictors of adult vector density or arbovirus transmission risk (Reiter and Gubler 1997). Furthermore, given the high mortality of *Ae. aegypti* at the larval stage, containers with pupae or the actual numbers of pupae may be more accurate indicators of adult vector density (Focks 2003, Barrera et al. 2006). Containers with pupae were rare in Tucson, however, limiting the statistical power of analyses.

Several housing features showed significant associations with container variables. The neighborhood in which the house was located was significant across all four container variables, indicating that both the degree of backyard clutter and the density of *Ae. aegypti* varied among neighborhoods. Homes that were owned by the resident rather than rented had more total containers, more containers with water and were more likely to have *Ae. aegypti* pupae, presumably because rental properties tend to be cleared out between renters. The marginally positive association observed between the percent of yards with vegetation and the presence of *Ae. aegypti* larvae matches earlier work by Hayden et al. (2010) in the Arizona/Sonora border region. There were no significant associations, however, between other housing features (single vs. multi-family houses, house age, percent of yard shaded) and any container response variables.

Demographic and human behavior factors were also significantly associated with container numbers and mosquito presence. Predictably, households that used a yard service had fewer containers than households that did not. There was no association, however, between use of a yard service and *Ae. aegypti* presence. Households with more people also had more total containers and were more likely to have containers with *Ae. aegypti* larvae. As has been observed in other studies of *Aedes* and *Culex* container-breeding mosquitoes in the United States (Chambers et al. 1986, Rios et al. 2006), household income was negatively associated with total container abundance and the abundance of containers with *Ae. aegypti*. It is interesting that lower income households tended to have more flower pots. While our study did not explore this issue, it is possible that in dry climates such as southern Arizona, extensive gardening requires significant investments in irrigation. Growing plants in flower pots may represent a more economical option for gardeners, but also increases vector habitat.

The inconsistent associations between reported frequency of checking for standing water and some of the container response variables suggest that self-reporting of this behavior is not an accurate measure of *Ae. aegypti* mosquito habitat density in this region. These findings are similar to those observed by Tuiten et al. (2009) for *Culex pipiens* (L.; Diptera: Culicidae) in New York, but differ from those found for *Cx. pipiens* and *Ae. albopictus* by Dowling et al. (2013) in Washington, DC. In neighborhoods where mosquito indices are higher, individuals may check water sources more frequently but miss key container habitats. In addition, some respondents may not have described their behavior accurately due to a social-responsibility response bias in which respondents give answers they perceive as more favorable to the interviewer (Fisher 1993). Respondents were asked about checking for standing water after questions about where mosquitoes lay their eggs, thus directly connecting mosquitoes to standing water sources.

The study had certain limitations. Those houses in which only the front yard could be inspected (usually due to aggressive dogs) had consistently fewer containers and *Ae. aegypti* immatures, indicating that partial sampling resulted in underestimation of mosquito habitat. Future studies may be advised to omit respondents who cannot provide access to the whole yard. There was also a significant surveyor effect, with some surveyors finding more containers and mosquitoes on average than others. Although all surveyors received training, the differences among surveyors could be attributed to how thorough each surveyor was in checking for containers, or how they classified potential containers. Finally, we did not compare all possible subset of models when selecting the inferential models to analyze associations between human factors and vector habitat reported in Tables 2 and 3. Accordingly, each of these inferential models should be considered as one of several models that could have been used to evaluate effects of the explanatory variables (Ramsey and Shafer 2002).

The key findings of this study can inform future *Ae. aegypti* surveillance and control efforts in arid environments. Our study identified flower pots and associated saucers as a key larval habitat, information that can be used for more targeted public health messaging to residents as well as plant nurseries and related businesses. Our results also indicate that, at least in this southwestern U.S. city, the accumulation of trash and other unwanted containers is not linked to increased *Ae. aegypti* infestation. This study also did not find a consistent association between self-reported frequency of checking for standing water and potential or actual *Ae. aegypti* habitat. The negative association between *Ae. aegypti* presence and income suggests that focusing surveillance and management efforts on lower income areas may maximize the impact of vector control efforts.

Acknowledgments

Funding support for this work was provided by NIH-NIAID grants R56AI091843 and R01AI091843. We would like to thank University of Arizona students Amit Arora, Brent Cook, Alex Dunn, Donna Feng, Etse Gebru, Andrea Mannell, Hilary Rees, Adam Resnick, and Laura Tippit for field data collection as well as the Tucson residents who participated in the survey.

Supplementary Data

Supplementary data are available at *Journal of Medical Entomology* online.

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