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SCIENTIFIC NOTE

SEASONAL OCCURRENCE OF IMMATURE MOSQUITOES IN SWIMMING POOLS IN BUENOS AIRES, ARGENTINA

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ABSTRACT. The seasonal variation in the density of swimming pools and the occurrence of immature mosquitoes in these habitats were studied in the temperate city of Buenos Aires, Argentina. The density of swimming pools was highest in the summer (6.0 pools/ha) when temporal pools predominated; it was lowest in the winter (0.9 pools/ha) when only permanent pools were recorded. The presence of immature stages of mosquitoes was mainly associated with the lack of use and maintenance of the pools in the fall season, when temporal pools were still assembled but not intensively used. Seven mosquito species were recorded, among which *Culex pipiens* and *Culex apicinus* were the most frequent.

KEY WORDS Culicidae, *Culex*, *Aedes*, urban swimming pools, Argentina

The importance of swimming pools as mosquito breeding sites has been recognized in recent years by public health authorities and researchers in different countries, mostly related to the spread of pathogens transmitted by mosquitoes, such as *Plasmodium* spp. in Africa (Keating et al. 2004), or West Nile virus in the United States (Reisen et al. 2008).

In temperate regions, the recreational use of swimming pools is expected to be concentrated in the summer months with a gradual decrease through the fall, and reduction to zero in the winter. During the period when they are in use, owners make a considerable effort to maintain and clean the water by removing leaf litter and insects and by treating with chlorine. Most likely, during the remaining seasons these maintenance activities are significantly reduced, thus turning swimming pools into suitable habitats for mosquito larvae. Indeed, studies in different countries have reported that the presence of mosquitoes in swimming pools is closely related to poor or no pool maintenance (Keating et al. 2004, Caillouët et al. 2008, Impoinvil et al. 2008, Reisen et al. 2008).

The aim of the present work is to describe the seasonal variation in the density of swimming pools as well as the occurrence of immature mosquitoes in these habitats in the city of Buenos Aires, Argentina.

The city of Buenos Aires covers an area of 200 km^2 and has a population of 3 million people. There are 4 clearly distinguishable seasons related to temperature differences. Mean summer temperatures are 23.6°C, fall 17.8°C , winter 11.5°C, and spring 17.3°C . Rainfall occurs year round, and there is no rainy season (National Meteorological Service 2009).

In this study, a total of 5,127 houses in 130 different neighborhoods were surveyed from June 1998 through April 2002, covering an area of 83.5 ha. Sampling efforts were higher during the summer (46 neighborhoods covering 34.3 ha) and fall (41 neighborhoods covering 24.5 ha), and lower during the winter (23 neighborhoods covering 12.0 ha) and spring (20 neighborhoods covering 12.6 ha). In each house the presence or absence of a swimming pool was recorded. For each pool the water level was classified into one of 3 categories: empty (without water), partially filled ($<$1/3 filled with water), or filled ($\geq$1/3 filled with water). Owners were asked whether pools were in use for recreation activities at the time of the survey. The type of pool was classified as permanent (pools made from building material, glass fiber, or solid plastic that are necessarily present during the whole year), or temporal (pools made from canvas that can be taken apart and stored during the unfavorable season). Unfortunately, not all the field assistants recorded this variable; therefore, this information was only available for a subsample of the pools (57%). All pools were inspected for immature stages of mosquitoes, and qualitative samples were taken with a small mesh sieve. The samples were fixed in situ in 80% ethanol. In the laboratory, immature mosquitoes were sorted by stage and identified to genus level for instars 1–2 and pupae, and to species level for instars 3–4 (Darsie 1985, Almirón and Brewer 1995, Almirón and Harbach 1996).

The total densities of pools and of pools with immature mosquitoes in each neighborhood were assessed by dividing either the number of pools or the number of mosquito-positive pools by the

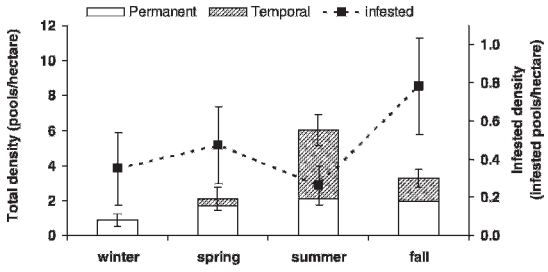

Fig. 1. Mean densities of swimming pools (bars) distinguishing temporal and permanent ones, and of pools with mosquito immature stages (line) in each season (error bars correspond to standard errors).

total surveyed area in the corresponding neighborhood. Total pool densities were compared by season using the Kruskal–Wallis test. Post hoc multiple comparisons of mean ranks were conducted using the Dunn test. The proportions of temporal pools for each season were assessed by dividing the number of temporal pools by the sum of temporal and permanent pools recorded each season.

Pools containing water and mosquito-positive pools were classified according to season, use, and water level described above. Proportions of pools with mosquito stages were compared among categories of each variable (season, use, filling) by means of a chi square test for independent proportions (all species together and each species separately). This test is comparable to computing the Pearson chi square statistic for contingency tables. Differences among pairs of seasons were examined by subdividing the contingency tables and computing the chi square value on the partial tables.

The highest pool density was recorded during the summer with a mean value of 6.0 pools/ha, and the lowest pool density was found in the winter, having a mean of 0.9 pool/ha (Fig. 1). Pool densities showed significant seasonal changes (Kruskal–Wallis test: df = 3, n = 130, H = 33.71, $P < 0.001$). Post hoc analysis showed significant differences for the summer pool density as compared with the winter and spring densities ($P < 0.001$ and $P < 0.005$ respectively). Significant differences were also detected between the fall and the winter season ($P < 0.05$). Temporal pools, which accounted for 2/3 of the pools surveyed, peaked during the summer but there were none during the winter (Fig. 1).

The density of pools with immature mosquitoes was the lowest during the summer, but highest during the fall and level during the winter and spring seasons (Fig. 1).

Twenty-two of the pools recorded were dry, and 33 of the 286 pools with water (11.5%) had immature mosquitoes. Seven mosquito species belonging to the *Culex* and *Aedes* genera were identified. The dominant species were *Culex pipiens* L., and *Culex apicinus* (Philippi), present in 61% and 39% of the samples respectively. A lower percentage of samples contained *Culex maxi* Dyar (24%), *Culex dolosus* (Lynch Arribálzaga) (21%), *Aedes aegypti* (L.) (15%), and *Culex tatoi* Casal and García (9%); *Culex chidesteri* Dyar was present in a single sample.

Mosquito immature stages were present in all seasons, water level, and use categories (Table 1), although in varying proportions. Significantly higher proportions of pools with mosquitoes were detected in the fall, winter and spring as compared to the summer ($\chi^2 = 32.76$, df = 3, $P < 0.001$). Similar pattern were observed for *Cx. pipiens* ($\chi^2 = 32.25$, df = 3, $P < 0.001$), and *Cx. apicinus* ($\chi^2 = 27.26$, df = 3, $P < 0.001$). *Culex maxi* attained higher proportions in the fall ($\chi^2 = 11.21$, df = 3, $P < 0.025$), *Cx. dolosus* in the fall and spring ($\chi^2 = 15.49$, df = 3, $P < 0.005$), *Cx. tatoi* in the winter ($\chi^2 = 26.53$, df = 3, $P < 0.001$), and *Cx. chidesteri* in the spring ($\chi^2 = 12.04$, df = 3, $P < 0.025$). No significant differences among seasons were detected for *Ae. aegypti*.

The proportion of pools with mosquitoes was higher in the partially filled pools than in filled pools when considering all species together ($\chi^2 = 5.59$, df = 1, $P < 0.025$). The same was observed for *Cx. pipiens* ($\chi^2 = 5.70$, df = 1, $P < 0.025$) and *Ae. aegypti* ($\chi^2 = 7.27$, df = 1, $P < 0.01$), analyzed separately. The remaining 5 species showed no association with any water category. On the other hand, pools that were unused at the time of the survey attained higher proportions of infestation than pools that were in use when considering all species together ($\chi^2 = 48.85$, df = 1, $P < 0.001$), in coincidence with the results for the 4 most frequent species: *Cx. pipiens* ($\chi^2 = 29.51$, df = 1, $P < 0.001$), *Cx. apicinus* ($\chi^2 = 16.56$, df = 1, $P < 0.001$), *Cx. maxi* ($\chi^2 = 21.57$, df = 1, $P < 0.001$), and *Cx. dolosus* ($\chi^2 = 12.11$, df = 1, $P < 0.001$).

According to the data, the seasonal variations in pool density could be related to the varying abundance of temporal pools (such as pools made from canvas), which are taken apart and stored at the end of the warm season. The highest density period is coincident with the school holiday period in this region, which starts the 2nd week of December and goes through the 1st week of March. It is noteworthy that the decrease in maintenance and use of these pools when temperature drops may have provided favorable conditions for mosquito colonization. Thus, it seems that the most favorable season for mosquito breeding in residential swimming pools is not the highest pool density season, but the time when pools are not used but still assembled or containing water.

The results of the present study indicate in Buenos Aires there are 1–3 pools functioning as breeding sites for immature mosquitoes every 4

Table 1. Number of swimming pools with water and immature mosquitoes recorded by season, use, and water level.

	Season				Use		Water level	
	Winter	Spring	Summer	Fall	In use	Unused	Filled	Partially filled
No. of pools with water	8	22	185	71	207	79	240	46
No. of pools with mosquitoes	4	6	8	15	7	26	23	10
Species	Winter	Spring	Summer	Fall	In use	Unused	Filled	Partially filled
Culex pipiens	3	5	2	10	4	16	13	7
Cx. apicinus	1	5	1	6	3	10	10	3
Cx. maxi	0	0	2	6	0	8	6	2
Cx. dolosus	0	3	1	3	1	6	7	0
Cx. tatoi	1	2	0	0	1	2	3	0
Cx. chidesteri	0	1	0	0	0	1	1	0
Aedes aegypti	0	0	3	2	2	3	2	3

blocks (4 hectares) during the lowest (summer) and highest (fall) periods respectively. Such densities imply that every point in the city is within a distance of 65–110 m of a pool breeding mosquitoes. Taking into account that the known dispersal ranges of several mosquito species exceed such distances (Service 1997), the influence of swimming pools may extend to every point across the city.

From the 30 species reported in recent years in Buenos Aires (Fontanarrosa et al 2004, Loetti et al. 2007, Freire and Schweigmann 2009), 7 (23%) were recorded in the present study. *Culex apicinus* and *Ae. aegypti* seem to be restricted to container habitats, whereas the remaining 5 species recorded in this study are usually observed in a more diverse range of habitats in Buenos Aires, from permanent wetlands (with or without vegetation cover) to temporary pools (Fontanarrosa et al. 2004).

Culex pipiens, the most frequent species in the present study, is a recognized vector of several diseases, including western equine encephalitis virus, West Nile virus, and Saint Louis encephalitis. *Aedes aegypti* is also related to the transmission of numerous diseases among which the most widespread are probably dengue fever and the urban cycle of yellow fever. Nevertheless, because a relatively low proportion of *Ae. aegypti* were found in swimming pools, these would not be important breeding sites in Buenos Aires City. Until now, no information on the transmission capacity of the remaining 5 species is available, mainly because they are endemic to the southern part of South America and, therefore, not exhaustively studied as compared to more widespread species.

The results of the present study are preliminary, and provide the 1st records of mosquito composition and seasonal prevalence in swimming pools of Buenos Aires City. Therefore, some aspects such as productivity of adult mosquitoes, composition and abundance of natural predators, or their efficiency to control immature mosquitoes in this kind of habitat were not assessed. Studies on this subject would be of great importance in order to assess the feasibility and efficiency of different prevention and control strategies.

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