Evaluation of predictive maps for *Aedes aegypti* larval habitats in two urban areas of Costa Rica

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Abstract

The abundance of *Aedes aegypti* can be associated with urban structure and tree cover, which conceals and protects containers. The purpose of this study was to create and evaluate predictive maps for *Ae. aegypti* larval habitats in Puntarenas and Carpio, two very different urban environments in Costa Rica. Linear regression models for number of mosquito larval habitats had been developed for Puntarenas, and they showed a significant association with tree cover. Parameters from the model and data from land cover maps were used to create predictive maps for the expected number of *Ae. aegypti* positive larval habitats in all cells that cover the urban areas. To evaluate maps, cells were stratified in four categories of risk (low, medium, high, and very high) and randomly selected for entomological evaluations. In Puntarenas, 382 wet containers were identified (22.5% with *Ae. aegypti*). Expected and observed categories of *Ae. aegypti* larval habitats per cell in Greater Puntarenas were significantly correlated (p=0,037). Only 32% of cells harbored the exact number of expected habitats, 81% contained the expected number +/- 2 habitats, and only 16% underestimated total larval habitats. In Carpio, 693 wet containers were identified (11.4% positive). Expected and observed categories of *Ae. aegypti* positive habitats per cell were not significantly correlated in Carpio. Only 50% of cells contained the expected number +/- 2 habitats, and 29% underestimated the total observed. The most frequent *Ae. aegypti* larval habitats in Puntarenas included plastic and miscellaneous containers, while many larval habitats in Carpio were commonly human-filled, such as drums. These maps and models may be considered adequate for areas like Puntarenas, whereas they do not seem to apply for Carpio. Tree cover may provide useful information in sites where *Ae. aegypti* larval habitats include mostly outdoor rain-filled containers, as opposed to sites where containers are greatly affected by the need for water storage.

Tree cover and other characteristics of urban structure have been associated in urban environments with abundance and productivity of *Aedes aegypti* and other mosquito larval habitats. Tree cover can affect suitability of larval habitats: conceal containers, protect them from direct sunlight and desiccation, provide debris for larval nutrition, and promote adult survival by providing resting sites.[1,2,3]

Dengue is a major public health concern in Costa Rica, and *Ae. aegypti* is the principal vector.[4] Tree cover has been associated with larval habitats of the vector,[5] and maps for expected *Ae. aegypti* larval habitats have been obtained using parameters from linear regression models. The purpose of this study was to evaluate these predictive maps for *Ae. aegypti* larval habitats in Puntarenas and Carpio, two very different urban environments in Costa Rica (Fig. 1).

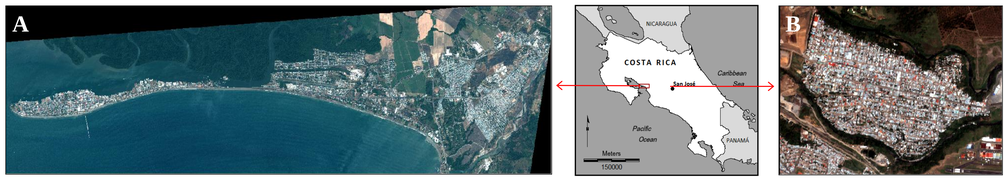

Fig. 1. Greater Puntarenas (A) and Carpio (B), Costa Rica. Color composites (Quickbird multispectral imagery).

Materials and Methods

Linear regression models for number of mosquito larval habitats that showed a significant association with tree cover had been developed for Puntarenas ($R^2 = 0.650$, $p<0.001$). Predictive maps for the expected number of *Ae. aegypti* positive larval habitats in 50 by 50 m cells that cover the urban areas were created using parameters from the model and data extracted from land cover maps (2.4 m spatial resolution Quickbird satellite imagery) of both areas (Fig. 2).

The final maps for expected number of larval habitats containing *Ae. aegypti* were evaluated during the wet season of 2010 by performing entomological field evaluations on a sample of 50 by 50 m cells, as has been described previously.[6] Four categories were created for the number of larval habitats per cell: low (0-1), medium (2-3), high (4-5), and very high (6 or more). For evaluations, 51 and 24 cells were selected by stratified random sampling in Greater Puntarenas and Carpio, respectively. All larval habitats within cells were identified, and a sample of mosquito larvae was collected when present in order to identify *Ae. aegypti*. The number of *Ae. aegypti* positive larval habitats was determined for each cell and compared to the expected number of habitats obtained from the maps. Spearman correlation coefficient was also determined to compare expected and observed categories of each cell.

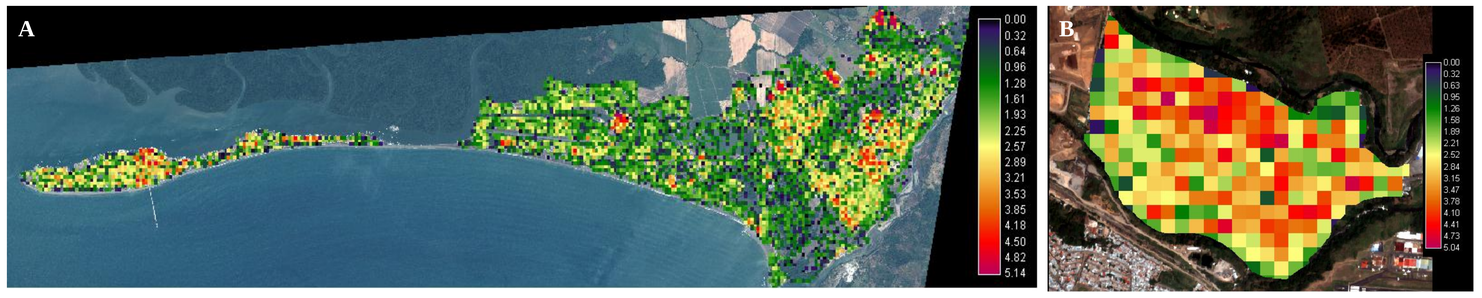

Fig. 2. Expected *Ae. aegypti*-positive containers per 50 by 50 m cells in Greater Puntarenas (A) and Carpio (B), Costa Rica.

Table 1. Types of *Aedes aegypti*-positive containers in Greater Puntarenas and Carpio, Costa Rica.

	Total *Ae. aegypti* positive containers (%)	
Container type	**Greater Puntarenas**	**Carpio**
Gutter/ sewer	2(2.3)	0 (0)
Bucket	5 (5.8)	12 (15.0)
Animal drinking	2 (2.3)	0 (0)
Bottle	4 (4.7)	4 (5.0)
Roof gutter	3 (3.5)	1 (1.3)
Coconut	6 (7.0)	0 (0)
Drum	0 (0)	22 (27.5)
Vase/plant in water	0 (0)	1 (1.3)
Tin/plastic small container	21 (24.4)	5 (6.3)
Tire	3 (3.5)	14 (17.5)
Flower pot	8 (9.3)	1 (1.3)
Other	29 (33.7)	20 (25.0)
Wash tub	3 (3.5)	0 (0)
Total	86 (100)	80 (100)

Results

Puntarenas: 382 wet habitats were identified. One cell (outlier) was excluded.

- Expected and observed categories of *Ae. aegypti* larval habitats per cell were significantly correlated (p=0.037).
- Only 16 cells (32%) harbored the exact number of expected *Ae. aegypti* positive habitats, although 29 (58%) contained the expected number +/- 1 habitat and 41 cells (82%) +/- 2 habitats. Thirteen cells (26)% were overestimated by more than 1 habitat, although the estimate was greater than observed by more than 2 in only 5 cells. In 8 cells (16%) the map underestimated the expected number of positive containers by more than 1.
- *Aedes aegypti* container index in Greater Puntarenas was 22.5%, Breteau index was 43.7, and the most frequent *Ae. aegypti* habitats were outdoor miscellaneous and small plastic containers that fill with rain water (Table 1).

Carpio: 693 wet habitats were identified.

- Expected and observed categories of *Ae. aegypti* larval habitats per cell were not significantly correlated.
- Only 7 cells (29%) harbored the number of expected *Ae. aegypti* positive habitats +/- 1 habitat and 12 (50%) cells +/- 2 habitats. In an additional 5 cells (21%), the predictive map overestimated the expected number of positive habitats by more than 2, and in 7 (29%) it underestimated the expected positive containers by more than 1.
- *Aedes aegypti* container index was 11.4%, Breteau index was 24.7, and among the most important containers with *Ae. aegypti* in Carpio were drums and buckets that are filled manually due to problems with the water service (Table 1).

Conclusions

Evaluations showed that the predictive maps generated for Greater Puntarenas using tree cover and built area can be considered useful for determining high and low levels of expected *Ae. aegypti* larval habitats, as well as roughly estimating the number of containers within +/- 2 habitats in approximately 82% of cells. Although tree cover can directly affect mosquitoes and suitability of larval habitats,[1,2] it can also reflect local conditions that increase the likelihood of finding larval habitats (such as larger back yards with shaded areas).[3] Considering the potential effect of ongoing vector control on overestimation and the greater impact of underestimation, it is possible to conclude that the map of Greater Puntarenas may be useful up to approximately 86%. In contrast, the maps for Carpio were not adequate, due in part to the differences in container profiles. Therefore, maps show that tree cover may provide useful information in sites where *Ae. aegypti* larval habitats include mostly outdoor rain-filled containers, as opposed to sites where containers are greatly affected by the need for water storage. Additional variables and local information should be analyzed and included to improve the maps. Where adequate, maps such as these can be used to aid surveillance efforts and to determine key areas where dengue vector control efforts can be directed. They can be especially useful in locations where vector surveillance is difficult or lacking. This approach may be applicable to other urban areas in Costa Rica and the Region, where dengue is a serious public health problem.

References:

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