Reducing *Culex erythrothorax* at a freshwater marsh using larvicide, physical control, and traps

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INTRODUCTION

Culex erythrothorax Dyar, the tule mosquito, is a competent vector of West Nile virus and can be highly abundant in marsh habitats with dense stands of bulrush and other vegetation (Walton and Workman 1998, Tietze et al. 2003, Counts and Peavey 2006). Aquatic vegetation serves as a refuge for larval and adult *Cx. erythrothorax*, but can obstruct liquid or granular larvicides from entering the water, thereby limiting their impact on reducing mosquito abundance. Environmental temperatures below 50 °F slow mosquito development substantially (Bar-Zeev 1958, Loetti et al. 2011). Growing Degree Days base 50 °F (GDD) is a summary heat index that measures heat accumulation in the environment when surface temperatures exceed 50 °F (McMaster and Wilhelm 1997), allowing for mosquito growth.

METHOD

The study site was a 28 acre freshwater marsh that abuts the San Francisco Bay (GPS coordinates near the midpoint of the study site are 37.629926, -122.139293). Each week, when weather conditions were favorable, 8.8 lbs / acre of VectoMax, VectoBac G, or VectoLex CG was applied at the site to reduce *Cx. erythrothorax* abundance. To determine if one product was more efficacious than another, and to limit the potential for insecticide resistance, the larvicide products were rotated each week (Figure 1A). To evaluate the efficacy of EVS CO_2 and Mosquito Magnet (MM) traps in attracting *Cx. erythrothorax*, EVS traps were placed approximately 50 m on either side of a MM that was positioned in the freshwater marsh. EVS traps were provisioned with dry ice, and the trap contents of the EVS and MM collected daily. The collected mosquitoes were identified to species using a dissection microscope. Mosquito abundance was reported as females per trap-night +/- standard error of the mean (SEM). GDD values were calculated from temperature data collected at a weather station located at the Hayward Executive Airport, approximately 2 mi northeast of the study site (Weather Underground)

RESULTS

During weeks 17 – 26 of 2016, *Cx. erythrothorax* were highly abundant at the marsh site (521 +/- 319 mosquitoes / trap night; Figure 1A, left y-axis). After two larvicide applications, there was a 23-fold reduction in adult *Cx. erythrothorax* abundance at the site (Figure 1A). The reduced mosquito abundance from week 30 – 34 did not coincide with a reduction in GDD (Figure 1A, right y-axis). Although larvicide applications continued for subsequent weeks, mosquito abundance returned to pre-treatment levels by week 37 (Figure 1A). High *Cx. erythrothorax* abundance at the site (1780 +/- 360 mosquitoes / trap night) encouraged East Bay Regional Park District (EBRPD) to remove most of the tule plants from the marsh (Figure 1B). Removal of the tule from the site in combination with a reduction in GDD correlated with a 20-fold reduction in *Cx. erythrothorax* abundance during weeks 48 – 52 (91 +/- 43 mosquitoes / trap night; Figure 1A). During the subsequent year (2017), *Cx. erythrothorax* abundance at the study site remained low (71 +/- 19 mosquitoes / trap night). Comparison of the EVS CO_2 to MM traps showed the MM caught significantly more *Cx. erythrothorax* (Figure 1C).

DISCUSSION

Tule plant removal from a 10 foot wide ditch successfully limited *Cx. erythrothorax* breeding when the use of larvicides alone failed (Counts and Peavey 2006). However, physical removal of emergent vegetation to control mosquitoes in large ecologically sensitive habitats presents challenges to landowners and managers that seek to protect habitats which support threatened or endangered species. Intensive monitoring of mosquito abundance at the study site provided the data that motivated discussions with EBRPD staff, resulting in an outcome that substantially reduced *Cx. erythrothorax* in the area that could not be accomplished with larvicide applications alone. To suppress *Cx. erythrothorax* abundance in habitats where removal of emergent vegetation is not permitted or feasible, MM may be more effective than EVS CO_2 traps for reducing biting pressure from adult female mosquitoes.

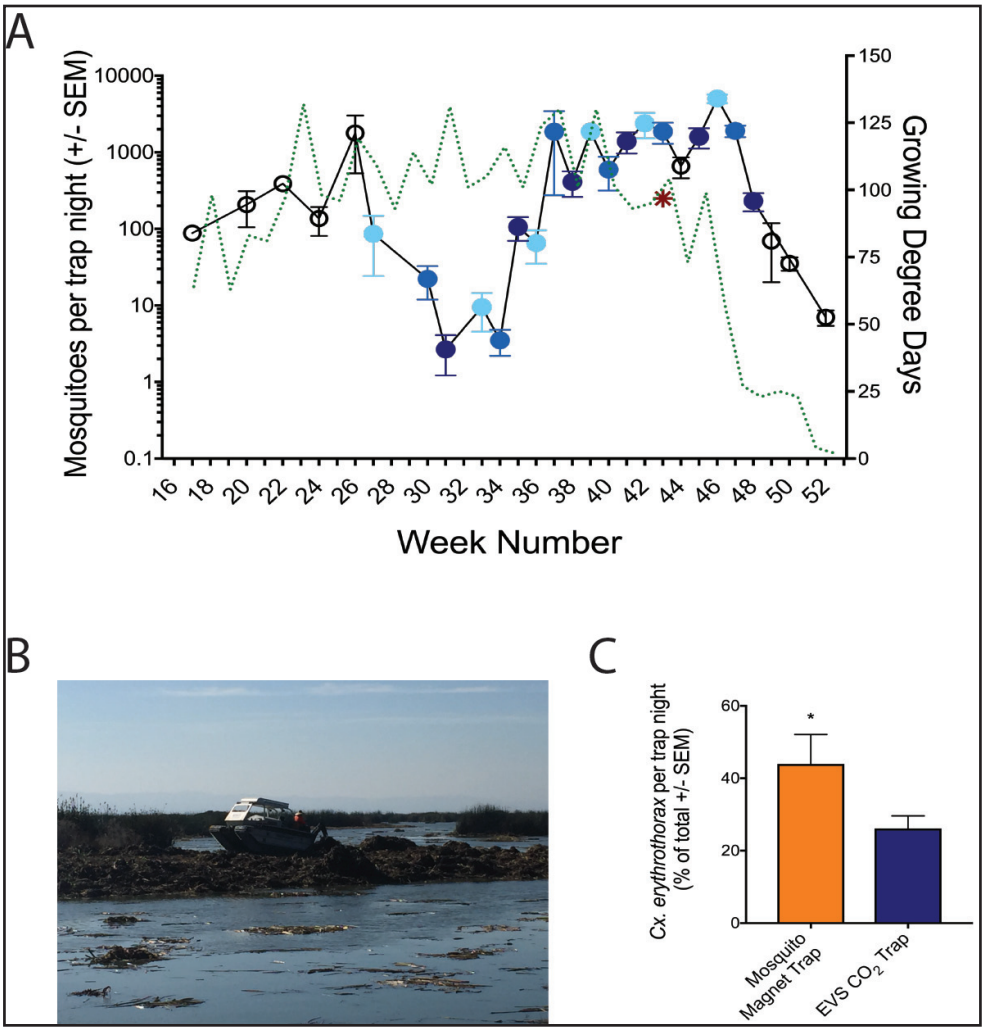

Figure 1 **Larvicide impact on *Cx. erythrothorax* abundance in a freshwater marsh and comparison of MM with EVS CO_2 traps for capturing *Cx. erythrothorax*.** (A) Larvicide applications reduced *Cx. erythrothorax* abundance for several weeks (left y-axis), but abundance increased until emergent vegetation was removed (indicated by red asterisk) and was followed by fewer growing degree days (right y-axis). (B) Physical removal of emergent vegetation from the freshwater marsh by EBRPD contractors. (C) MMT captured significantly more adult *Cx. erythrothorax* relative to CO_2 traps (paired t test, $P < 0.05$).

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