OPERATIONS NOTE

INCREASED WATER HARDNESS IN CATCH BASINS TREATED WITH SPINOSAD (NATULAR XRT) EXTENDED RELEASE TABLETS

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ABSTRACT

In response to apparent lack of efficacy of spinosad treatments of storm drain catch basins in Marathon, Florida, we investigated water quality parameters where drains had been treated with Natular® XRT extended release tablets. An analysis of water samples from these sites revealed that alkalinity and water hardness differed significantly between treated and untreated drains. However, when tested in a semi-field environment protected from runoff, differences in alkalinity were not associated with spinosad treatment, whereas water hardness increased over time in replicates treated with Natular XRT. Water quality may be a reason for poor larval control rather than product failure or resistance. Future work will investigate whether changes in water hardness associated with spinosad treatment may impact the efficacy of this larvicide at reducing adult emergence in field environments.

Key Words: spinosad, water hardness, pH, alkalinity, nitrate, nitrite, ammonia

The Florida Keys Mosquito Control District (FKMCD) includes Natular® XRT (Clarke, St. Charles, IL) extended release tablets in its larvicide arsenal. The active ingredient of Natular XRT is spinosad 6.25%, a mixture of spinosyns A and D derived from bacterial fermentation that may be ingested by larvae or absorbed by direct contact causing muscle spasms and eventually paralysis or death. Spinosad is a useful addition to the mosquito control toolbox, although it has a broader range of nontarget effects than other bacterial-derived larvicides (Lawler 2017). According to the product label, Natular XRT tablets may be placed into storm drain catch basins and allowed to dissolve into the standing water, providing up to 180 d of long-term mosquito control.

During 2017 we observed an apparent lack of efficacy in drains treated with Natular XRT tablets in FKMCD. We hypothesized that water chemistry in the treated locations could have interfered with the action of the formulation because water quality can affect solubility of spinosyns (Thompson et al. 1999). We conducted two experiments to investigate (1) whether water quality parameters in drains treated with Natular XRT tablets in the field differed from those in untreated drains, and (2) whether Natular XRT tablets themselves in a semi-field environment may be associated with changes in any water quality parameters identified in Experiment 1.

For Experiment 1 we selected two parking lots, one at the Government Center (GC; 9 drains present) and one at the Home Depot (HD; 16 drains present) in Marathon, Florida. We randomly selected 3 drains at GC and 8 drains at HD to be treated with Natular XRT tablets at the label rate, leaving the remaining 6 and 8 drains, respectively, as untreated controls. At 84 d post treatment we sampled water from all 25 drains and used aquarium testing reagents (Aquarium Pharmaceuticals, Inc., Chalfont, PA) to mea-

sure pH (hydrogen ion concentration), alkalinity (calcium carbonate concentration), hardness (calcium and magnesium concentration), and three indicators of decomposition of organic matter or fertilizer runoff (nitrite, nitrate, and ammonia) in each drain water sample. Prior to analysis, we log-transformed (log(x+1); GWMAP 1999) alkalinity, hardness, nitrite, nitrate, and ammonia data, and data for pH were backtransformed into hydrogen ion concentration (Fiorica 1968). We pooled data across the two sites and conducted an analysis of variance (SYSTAT 2009) to investigate differences in water quality parameters between treated and untreated control drains. The findings from Experiment 1, that is, identification of water quality parameters significantly different between treated and untreated control sites, were used to guide the selection of specific parameters tested in Experiment 2.

For Experiment 2 we set up a static semi-field system with six covered 5-gallon plastic buckets (Leaktite, Leominster, MA) at the Marathon FKMCD facility. Each bucket received 3 gallons of distilled water, and we then collected a 6 ml water sample from each bucket. We designated three buckets for immediate treatment with one Natular XRT tablet each and three buckets as untreated controls. We collected a 6 ml water sample from each of the six buckets daily for seven continuous days after the initial treatment day. Each water sample was tested immediately after collection for water quality parameters identified as significantly associated with Natular XRT treatment in Experiment 1.

Analysis of variance on data from drain water samples in Experiment 1 revealed significant differences ($P < 0.05$) in alkalinity and hardness in water collected in treated compared to untreated control drains (Table 1). We tested water samples from Experiment 2 for changes in these two parameters and found that alkalinity did not vary over the week, whereas general water hardness increased (R^2=0.9706) over the 7 d experiment (Figure 1). In a separate analysis (data not shown) we found that water quality parameters only significantly differed between the GC and HD sites in hydrogen concentration (pH), possibly attributable to different motor vehicle activities and consequent runoff solutes at the two sites (Alam et al. 2017).

The chemical composition of the Natular XRT tablet formulation is proprietary information but combined results from Experiments 1 and 2 suggest that the larvicide product application itself could have contributed to the observed differences in water hardness between treated and untreated control drains across the two study sites. Although both alkalinity and water hardness significantly differed between treated and untreated control drains in the field, the alkalinity did not significantly differ in treated buckets in the semi-field study. However, the buckets were protected from runoff and introduction of other material during the course of the study that may have, in contrast, affected this water quality parameter at the field sites.

Water quality in storm drain catch basins may be an important consideration in designing operational larvicide programs that include the active ingredient spinosad. It is known that solubility of spinosyns in water decreases as pH increases (Thompson et al. 1999, Cleveland et al. 2002, Liu and Li 2004,

Table 1. Analysis of variance of water quality parameters between treated and untreated control drains.

Parameter	TR[1] Mean ± SE	UT[1] Mean ± SE	F Ratio	P Value
Alkalinity	1.99 ± 0.01	1.52 ± 0.06	6.118	0.022
Hardness	1.86 ± 0.07	1.35 ± 0.07	5.248	0.032
Nitrite	0 ± 0	0.03 ± 0.01	1.394	0.251
Nitrate	0.12 ± 0.04	0.3 ± 0.4	0.228	0.638
Ammonia	0.27 ± 0.02	0.22 ± 0.01	0.026	0.875
Hydrogen	75.12 ± 3.14	65.81 ± 2.53	0.048	0.829

[1]TR, Treated; UT, Untreated

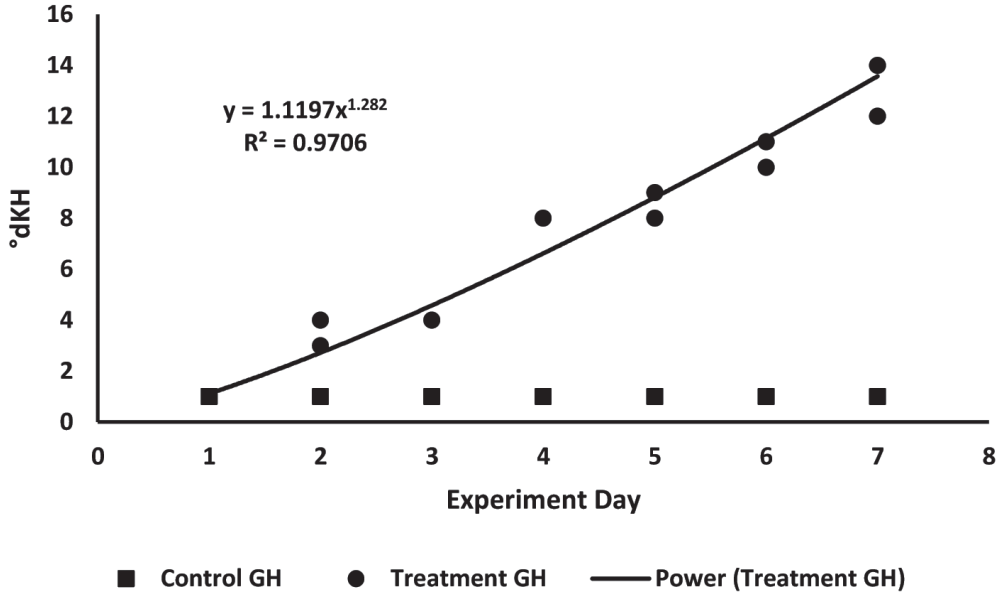

Figure 1. Change in general water hardness (GH) in Experiment 2. Data were plotted as degrees of carbonate hardness (°dKH) against time; °dKH may be converted to parts per million by multiplying by 17.848.

Adak and Mukherjee 2016). Mosquitoes are more likely to be found in catch basins with relatively low pH and high total suspended solids, carbon, and nitrogen (Butler et al. 2007, Gardner et al. 2013). Catch basins are designed to retain water and they also collect and retain debris, which may have an effect on performance of larvicides (Harbison et al. 2016). In this study we show that water hardness may be affected by the presence of the larvicide product itself. However, further work needs to be done to investigate whether changes in water hardness impact the efficacy of this spinosad formulation to inhibit adult emergence from treated standing water.

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