Defensiveness of the fire ant, *Solenopsis invicta*, increases during colony rafting

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Introduction: Colonies of the fire ant, *Solenopsis invicta*, can survive flood conditions by forming a mat, or raft, of tightly grouped ants that floats on the water's surface until the flood recedes or higher ground is found. Forced from the protection of their nests and left without retreat, rafting colonies are both exposed and cornered, and are thus more vulnerable to damage than they would be otherwise. As a logical corollary, **I tested the hypothesis that rafting colonies would compensate for their elevated vulnerability through an increase in worker defensiveness.** I measured defensiveness using the amount of venom workers deliver per sting (venom dose) since the pain and tissue damage caused by fire ant venom (i.e., its repellency) is dose-dependent[1].

Materials and Methods: Experimental colonies were collected from the field into buckets (nest soil included). In the lab, colonies were allowed at least 2 weeks to establish new nests in their buckets (during which time food and water were provided *ad libidum*). Foragers were removed by baiting before each experiment, since they are normally afield and thus not directly involved in nest defense (they have also been shown to deliver lower venom doses than nest-defenders[2]). Forty-five workers were then sting-sampled from each colony before, and again after, slowly flooding their buckets with water. Sting-sampling consisted of manually disturbing the colony and allowing defending workers to climb, one at a time, onto a latex glove to sting. Immediately prior to lancet insertion, a pH paper sting dummy (Fig. 1) was positioned between the workers and the glove. Each worker was allowed to sting its dummy 2-6 times, penetrating the thin silicone "skin" and leaving venom blots proportional in area to the volume of venom delivered. These blots were video-imaged and measured 24 hours later. Each worker's venom dose was calculated as the average area of its sampled stings converted to nl using the calibration equation[2]: area, $mm^2 = -0.432(nl^{1/3})^3 + 3.849(nl^{1/3})^2 + 0.799(nl^{1/3})$, $R^2 = 0.994$. The headwidths of sting-sampled workers were later measured to allow size-standardization of venom dose.

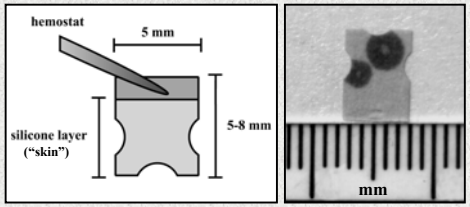

Figure 1. Sting dummies. Dummy in photo (right) was stung twice (silicone "skins" removed post-assay).

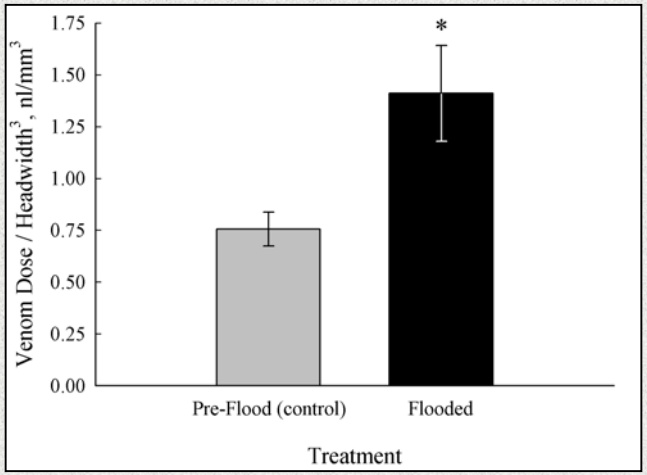

Figure 2. Size-Standardized Venom Dose by Treatment (means ± SE)**.** Each bar represents the mean of 5 colony means (n = 45 per colony). Venom dose from Flooded group is significantly greater than that of the Pre-Flood group (*paired t-test using colony means, n = 5, p = 0.008, one-tailed test). Venom dose is size-standardized using the cube of worker headwidth, shown to vary nearly directly with worker size as measured by dry weight[3].

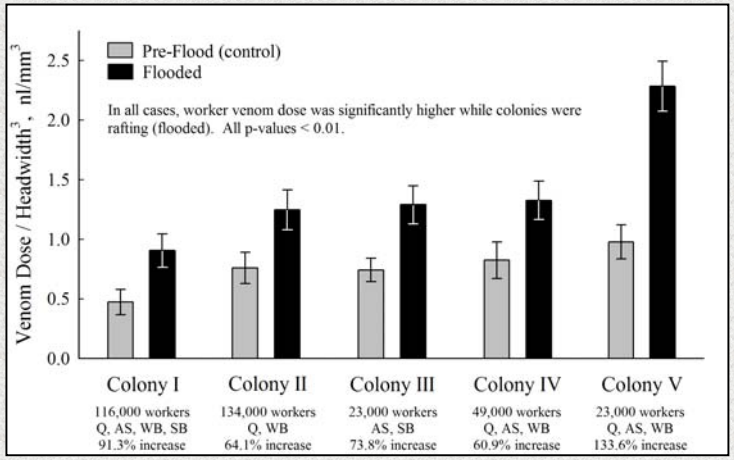

Figure 3. Size-standardized Venom Dose by Colony (means ± SE)**.** Each bar n = 45. Pre-Flood and Flooded groups were compared within colonies using one-tailed, two-sample t- or Mann-Whitney U tests. Individual colony attributes appear below colony labels: Q = queenright, AS = adult sexuals present, WB = worker brood present, SB = sexual brood present.

Results and Discussion: Workers consistently delivered significantly higher venom doses (~ 87% higher on average) while rafting than they did defending their nests pre-flood (Figs. 2 and 3). Mechanistically, the unusual concentration of workers during rafting may result in a concomitantly unusual concentration of alarm pheromones, and thus the increased defensiveness. Functionally, the increase in venom dose during rafting should serve to better protect the exposed colony from molestation. Previously reported observational data have suggested *S. invicta* workers increase their venom dose during periods of increased risk to colony assets (e.g. during the springtime production of sexuals[2]), but the present data are the first to show such an increase experimentally. From a practical standpoint, human encounters with fire ants during flood conditions have the potential to be unusually dangerous; not only are large concentrations of workers exposed and available for defense, but they deliver significantly larger venom doses when they sting.

References:

1. Read, G. W., Lind, N.K., and C.S. Oda, 1978. Histamine release by fire ant (*Solenopsis*) venom. *Toxicon* 16: 361-367.
2. Haight, K. L. and W. R. Tschinkel, 2003. Patterns of venom synthesis and use in the fire ant, *Solenopsis invicta*. *Toxicon* 42: 673-682.
3. Porter, S.D. and W.R. Tschinkel, 1985. Fire ant polymorphism: The ergonomics of brood production. *Behav. Ecol. Sociobiol.* 16: 323-336.