

# Supplementary Materials: Risk Assessment and the Effects of Refuge Availability on the Defensive Behaviors of the Southern Unstriped Scorpion (*Vaejovis carolinianus*)

David R. Nelsen, Emily M. David, Chad N. Harty, Joseph B. Hector and Aaron G. Corbit

**Table S1.** Fixed effects parameter estimates for all Poisson Generalized Linear Mixed Models.

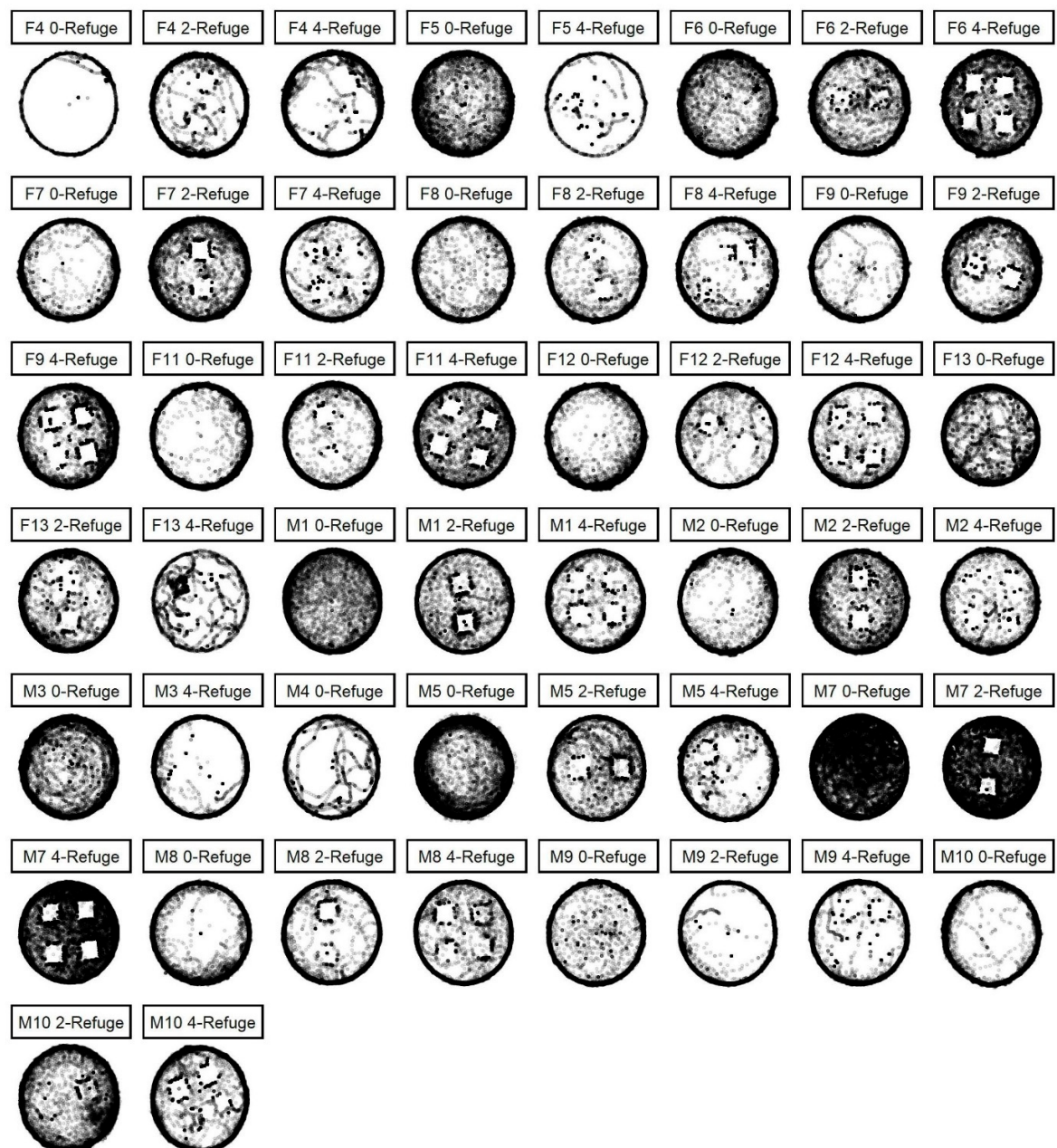
| Sting Frequency         |                      |          |      |                |                       |       |       |        |
|-------------------------|----------------------|----------|------|----------------|-----------------------|-------|-------|--------|
| Names                   | Effect               | Estimate | SE   | Exp( $\beta$ ) | Exp( $\beta$ ) 95% CI |       | z     | p      |
|                         |                      |          |      |                | Lower                 | Upper |       |        |
| (Intercept)             | (Intercept)          | 1.91     | 0.18 | 6.76           | 4.76                  | 9.59  | 10.71 | <0.001 |
| Refuge 1                | 2 - 0                | 0.05     | 0.09 | 1.05           | 0.88                  | 1.27  | 0.57  | 0.571  |
| Refuge 2                | 4 - 0                | 0.15     | 0.10 | 1.16           | 0.95                  | 1.42  | 1.43  | 0.152  |
| Prod Location 1         | metasoma - chela     | 0.33     | 0.08 | 1.39           | 1.18                  | 1.64  | 3.98  | <0.001 |
| Prod Location 2         | prosoma - chela      | 0.90     | 0.08 | 2.46           | 2.12                  | 2.85  | 11.99 | <0.001 |
| Sex 1                   | M - F                | 0.36     | 0.67 | 1.44           | 0.39                  | 5.38  | 0.54  | 0.588  |
| Mean Movement           |                      | 0.24     | 0.06 | 1.27           | 1.14                  | 1.42  | 4.20  | <0.001 |
| Observation Time        |                      | 0.01     | 0.01 | 1.01           | 0.99                  | 1.03  | 0.82  | 0.414  |
| Scorpion Length         |                      | 0.13     | 0.16 | 1.14           | 0.83                  | 1.57  | 0.80  | 0.426  |
| Refuge 1 $\times$ Sex 1 | 2 - 0 $\times$ M - F | -0.44    | 0.17 | 0.64           | 0.46                  | 0.89  | -2.64 | 0.008  |
| Refuge 2 $\times$ Sex 1 | 4 - 0 $\times$ M - F | -0.50    | 0.20 | 0.61           | 0.41                  | 0.91  | -2.44 | 0.014  |
| Pinch Frequency         |                      |          |      |                |                       |       |       |        |
| Names                   | Effect               | Estimate | SE   | Exp( $\beta$ ) | Exp( $\beta$ ) 95% CI |       | z     | p      |
|                         |                      |          |      |                | Lower                 | Upper |       |        |
| (Intercept)             |                      | -2.04    | 0.39 | 0.13           | 0.06                  | 0.28  | -5.19 | <0.001 |
| Refuge 1                | 2 - 0                | -0.11    | 0.38 | 0.90           | 0.43                  | 1.89  | -0.29 | 0.775  |
| Refuge 2                | 4 - 0                | -1.81    | 0.76 | 0.16           | 0.04                  | 0.73  | -2.37 | 0.018  |
| Prod Location 1         | metasoma - chela     | -2.23    | 0.61 | 0.11           | 0.03                  | 0.35  | -3.68 | <0.001 |
| Prod Location 2         | prosoma - chela      | -0.56    | 0.31 | 0.57           | 0.31                  | 1.06  | -1.78 | 0.076  |
| Sex 1                   | M - F                | -0.12    | 1.09 | 0.88           | 0.10                  | 7.48  | -0.11 | 0.909  |
| Mean Movement           |                      | 0.19     | 0.18 | 1.21           | 0.85                  | 1.72  | 1.04  | 0.297  |
| Observation Time        |                      | 0.10     | 0.06 | 1.10           | 0.98                  | 1.24  | 1.58  | 0.114  |
| Scorpion Length         |                      | 0.07     | 0.23 | 1.08           | 0.69                  | 1.68  | 0.32  | 0.749  |
| Refuge 1 $\times$ Sex 1 | 2 - 0 $\times$ M - F | -1.20    | 0.88 | 0.30           | 0.05                  | 1.68  | -1.37 | 0.171  |
| Refuge 2 $\times$ Sex 1 | 4 - 0 $\times$ M - F | -0.43    | 1.53 | 0.65           | 0.03                  | 13.01 | -0.28 | 0.778  |
| Venom Use               |                      |          |      |                |                       |       |       |        |
| Names                   | Effect               | Estimate | SE   | Exp( $\beta$ ) | Exp( $\beta$ ) 95% CI |       | z     | p      |
|                         |                      |          |      |                | Lower                 | Upper |       |        |
| (Intercept)             |                      | -2.08    | 0.33 | 0.13           | 0.07                  | 0.24  | -6.25 | <0.001 |
| Refuge 1                | 2 - 0                | 0.58     | 0.48 | 1.78           | 0.69                  | 4.59  | 1.19  | 0.232  |
| Refuge 2                | 4 - 0                | 0.15     | 0.69 | 1.16           | 0.30                  | 4.52  | 0.21  | 0.833  |
| Prod Location 1         | metasoma - chela     | -0.15    | 0.56 | 0.86           | 0.29                  | 2.55  | -0.28 | 0.782  |
| Prod Location 2         | prosoma - chela      | 1.01     | 0.44 | 2.73           | 1.15                  | 6.50  | 2.27  | 0.023  |
| Sex 1                   | M - F                | -1.53    | 0.90 | 0.22           | 0.04                  | 1.27  | -1.70 | 0.090  |

| Mean Movement    |               | 0.57     | 0.22 | 1.77   | 1.15          | 2.72  | 2.57  | 0.010  |
|------------------|---------------|----------|------|--------|---------------|-------|-------|--------|
| Observation Time |               | 0.03     | 0.04 | 1.03   | 0.95          | 1.11  | 0.64  | 0.521  |
| Scorpion Length  |               | 0.02     | 0.19 | 1.02   | 0.70          | 1.49  | 0.09  | 0.927  |
| Refuge 1 × Sex 1 | 2 - 0 × M - F | 1.62     | 0.97 | 5.06   | 0.75          | 33.95 | 1.67  | 0.095  |
| Refuge 2 × Sex 1 | 4 - 0 × M - F | −1.14    | 1.36 | 0.32   | 0.02          | 4.61  | −0.84 | 0.401  |
| <b>Cycle</b>     |               |          |      |        |               |       |       |        |
| Names            | Effect        | Estimate | SE   | exp(β) | Exp(β) 95% CI |       | z     | p      |
|                  |               |          |      |        | Lower         | Upper |       |        |
| (Intercept)      |               | 2.35     | 0.18 | 10.43  | 7.31          | 14.88 | 12.94 | <0.001 |
| Cycle 1          | 2 - 1         | 0.24     | 0.06 | 1.27   | 1.14          | 1.41  | 4.30  | <0.001 |
| Cycle 2          | 3 - 1         | −0.06    | 0.06 | 0.94   | 0.84          | 1.06  | −0.96 | 0.339  |

**Table S2.** Fixed effects parameter estimates for all Linear Mixed Models.

| Flee Duration    |                  |          |       |        |        |        |       |        |
|------------------|------------------|----------|-------|--------|--------|--------|-------|--------|
| Names            | Effect           | Estimate | SE    | 95% CI |        | df     | t     | p      |
|                  |                  |          |       | Lower  | Upper  |        |       |        |
| (Intercept)      |                  | 4.51     | 0.49  | 3.55   | 5.47   | 15.54  | 9.24  | <0.001 |
| Refuge 1         | 2 - 0            | 0.43     | 0.77  | −1.09  | 1.95   | 111.9  | 0.56  | 0.579  |
| Refuge 2         | 4 - 0            | 0.8      | 0.78  | −0.73  | 2.32   | 113.32 | 1.02  | 0.309  |
| Prod Location 1  | metasoma - chela | 4.45     | 0.74  | 3.01   | 5.9    | 104.15 | 6.03  | <0.001 |
| Prod Location 2  | prosoma - chela  | 4.67     | 0.74  | 3.21   | 6.13   | 104.24 | 6.28  | <0.001 |
| Sex 1            | M - F            | −1.21    | 2.24  | −5.61  | 3.19   | 17.54  | −0.54 | 0.596  |
| Mean Movement    |                  | −0.08    | 0.32  | −0.71  | 0.55   | 65.75  | −0.26 | 0.797  |
| Observation Time |                  | 0.06     | 0.08  | −0.1   | 0.22   | 109.16 | 0.77  | 0.444  |
| Scorpion Length  |                  | −0.17    | 0.54  | −1.23  | 0.9    | 16.82  | −0.31 | 0.764  |
| Refuge 1 × Sex 1 | 2 - 0 × M - F    | −2.61    | 1.54  | −5.63  | 0.4    | 114.89 | −1.7  | 0.092  |
| Refuge 2 × Sex 1 | 4 - 0 × M - F    | −0.36    | 1.61  | −3.51  | 2.79   | 112.35 | −0.22 | 0.824  |
| Latency to Sting |                  |          |       |        |        |        |       |        |
| Names            | Effect           | Estimate | SE    | 95% CI |        | df     | t     | p      |
|                  |                  |          |       | Lower  | Upper  |        |       |        |
| (Intercept)      |                  | 13.17    | 2.21  | 8.84   | 17.51  | 2.37   | 5.96  | 0.018  |
| Refuge 1         | 2 - 0            | −3.39    | 2.58  | −8.44  | 1.66   | 26.4   | −1.32 | 0.199  |
| Refuge 2         | 4 - 0            | −2.58    | 2.38  | −7.23  | 2.08   | 25.95  | −1.08 | 0.288  |
| Sex 1            | M - F            | 2.93     | 5.82  | −8.48  | 14.34  | 15.59  | 0.5   | 0.622  |
| Mean Movement    |                  | −2.1     | 0.9   | −3.87  | −0.33  | 37.8   | −2.33 | 0.026  |
| Scorpion Length  |                  | 1.41     | 1.4   | −1.35  | 4.16   | 14.28  | 1     | 0.333  |
| Refuge 1 × Sex 1 | 2 - 0 × M - F    | −4.18    | 4.9   | −13.78 | 5.43   | 26.47  | −0.85 | 0.402  |
| Refuge 2 × Sex 1 | 4 - 0 × M - F    | 0.82     | 4.7   | −8.4   | 10.04  | 24.34  | 0.17  | 0.863  |
| Latency to Pinch |                  |          |       |        |        |        |       |        |
| Names            | Effect           | Estimate | SE    | 95% CI |        | df     | t     | p      |
|                  |                  |          |       | Lower  | Upper  |        |       |        |
| (Intercept)      |                  | 69.73    | 9.06  | 51.97  | 87.48  | 7.67   | 7.70  | <0.001 |
| Refuge 1         | 2 - 0            | −30.10   | 11.32 | −52.28 | −7.92  | 15.61  | −2.66 | 0.017  |
| Refuge 2         | 4 - 0            | 17.13    | 11.33 | −5.08  | 39.34  | 14.89  | 1.51  | 0.152  |
| Sex 1            | M - F            | 27.07    | 40.78 | −52.85 | 106.99 | 15.76  | 0.66  | 0.516  |
| Mean Movement    |                  | −3.60    | 5.26  | −13.91 | 6.71   | 32.68  | −0.68 | 0.499  |
| Scorpion Length  |                  | 1.51     | 9.93  | −17.96 | 20.98  | 15.13  | 0.15  | 0.881  |
| Refuge 1 × Sex 1 | 2 - 0 × M - F    | 5.14     | 22.13 | −38.24 | 48.52  | 18.06  | 0.23  | 0.819  |
| Refuge 2 × Sex 1 | 4 - 0 × M - F    | 54.82    | 22.96 | 9.82   | 99.81  | 19.93  | 2.39  | 0.027  |
| Latency to Flee  |                  |          |       |        |        |        |       |        |
| Names            | Effect           | Estimate | SE    | 95% CI |        | df     | t     | p      |
|                  |                  |          |       | Lower  | Upper  |        |       |        |
| (Intercept)      |                  | 5.94     | 0.98  | 4.01   | 7.87   | 1.74   | 6.04  | 0.036  |
| Refuge 1         | 2 - 0            | 1.61     | 2.22  | −2.74  | 5.96   | 32.69  | 0.72  | 0.474  |
| Refuge 2         | 4 - 0            | −0.22    | 2.10  | −4.34  | 3.90   | 39.36  | −0.10 | 0.918  |
| Sex 1            | M - F            | −6.07    | 4.18  | −14.26 | 2.13   | 38.26  | −1.45 | 0.155  |
| Mean Movement    |                  | 0.52     | 0.73  | −0.92  | 1.95   | 38.41  | 0.70  | 0.486  |
| Scorpion Length  |                  | −1.42    | 1.00  | −3.38  | 0.53   | 38.31  | −1.43 | 0.161  |
| Refuge 1 × Sex 1 | 2 - 0 × M - F    | −2.33    | 4.36  | −10.87 | 6.21   | 39.98  | −0.53 | 0.596  |

| Refuge 2 × Sex 1     | 4 - 0 × M - F | −4.18    | 4.27 | −12.54 | 4.18  | 39.11 | −0.98 | 0.333  |
|----------------------|---------------|----------|------|--------|-------|-------|-------|--------|
| <b>Mean Movement</b> |               |          |      |        |       |       |       |        |
| Names                | Effect        | Estimate | SE   | 95% CI |       | df    | t     | p      |
|                      |               |          |      | Lower  | Upper |       |       |        |
| (Intercept)          |               | 3.31     | 0.28 | 2.76   | 3.86  | 12.50 | 11.87 | <0.001 |
| Refuge 1             | 2 - 0         | 0.50     | 0.37 | −0.23  | 1.22  | 17.58 | 1.35  | 0.195  |
| Refuge 2             | 4 - 0         | −0.10    | 0.38 | −0.85  | 0.64  | 17.76 | −0.27 | 0.787  |
| Sex 1                | M - F         | 0.36     | 0.56 | −0.73  | 1.46  | 12.50 | 0.65  | 0.528  |
| Refuge 1 × Sex 1     | 2 - 0 × M - F | −0.44    | 0.74 | −1.89  | 1.01  | 17.58 | −0.60 | 0.559  |
| Refuge 2 × Sex 1     | 4 - 0 × M - F | 0.89     | 0.76 | −0.59  | 2.38  | 17.76 | 1.18  | 0.255  |



**Figure S1.** Movements of the scorpion, *Vaejovis carolineanus*, during the overnight acclimation period of 50 experimental trials. Plots are based on X/Y coordinates obtained from video footage using a frame subtraction algorithm in MATLAB. Darker areas represent locations where the scorpion visited more frequently, and white areas represent areas the scorpion was not observed. Labels show scorpion sex (M or F), numeric identifier, and the number of refuges present in the arena.